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A World Review of

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VOL. XXII No. 1 JANUARY, 1961

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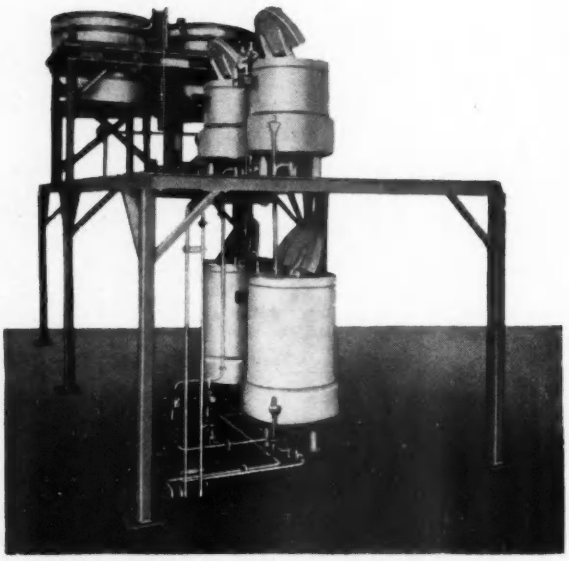

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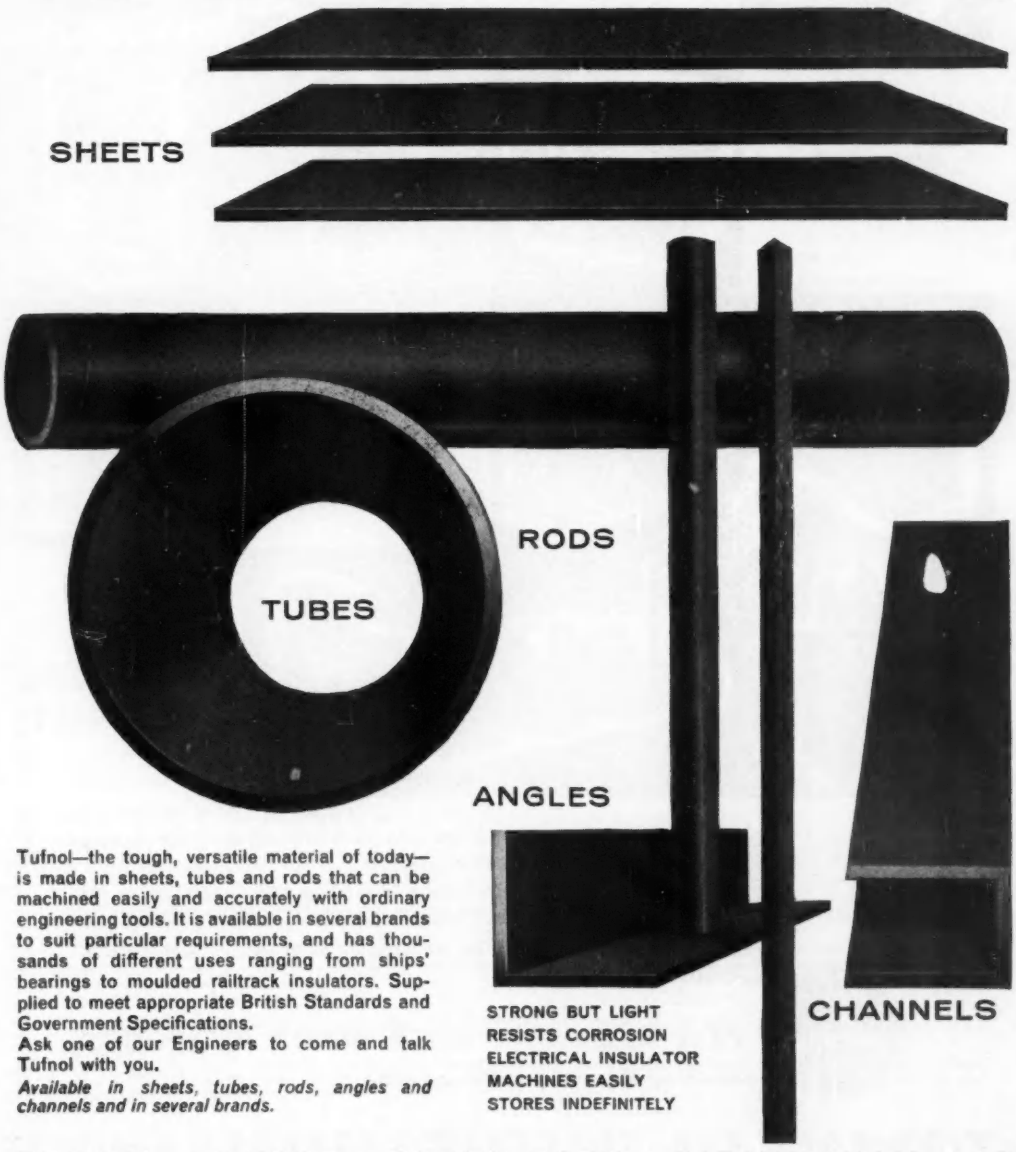

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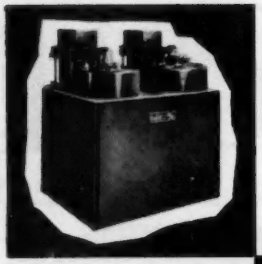

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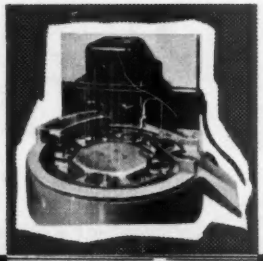

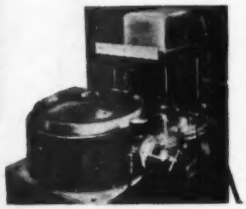

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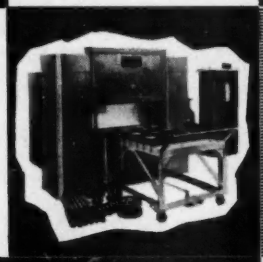

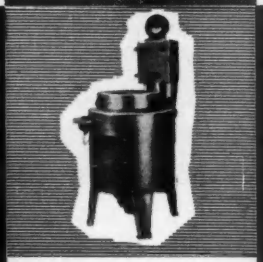

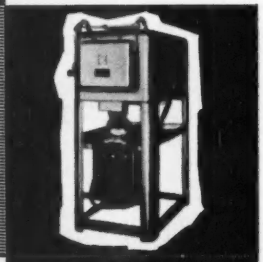

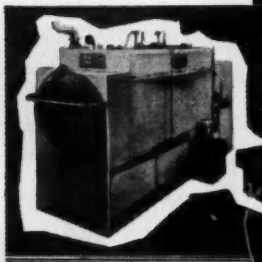

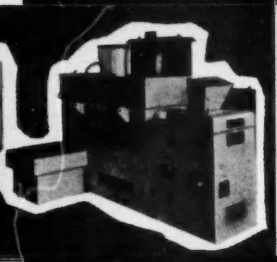

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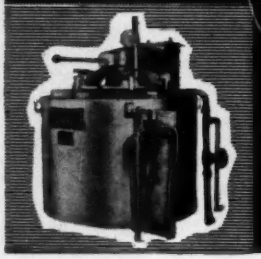

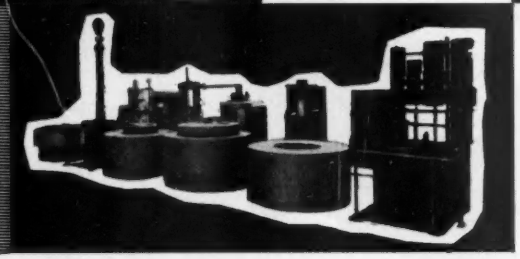

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The MINIDIGEST

An article in *Stal* (No. 11, 1960) contains details of a series of experiments carried out in Russia in connection with the **effect of rare-earth additions on the properties of chrome-nickel-molybdenum steel.** In some of these experiments, the steel was melted in an induction furnace under a vacuum of 2 to 7 mm Hg and, after adding various percentages of rare earths, mainly cerium and lanthanum, the steel was poured into moulds under an argon atmosphere. In other experiments, tests were carried out under actual operating conditions, using a conventional open-hearth furnace for melting a chrome-nickel-molybdenum steel containing 0·41% carbon with additions of aluminium and a mixture of rare earths. All these experiments have established that the treatment of chrome-nickel-molybdenum steel with rare-earth additions substantially reduces sulphur content, improves homogeneity, reduces anisotropy, and increases both the impact strength and the elastic properties of the steel by a factor of from 1·5 to 2.

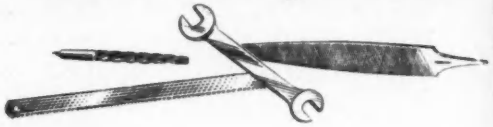
* * *

A ceramic-shell process has been developed in the U.S.A. by the Arwood Corporation, of Groton, Conn., which is claimed to be suitable for the production of large investment castings of intricate shape weighing up to 100 lb with normal tolerances. The process, which is stated to be applicable to practically all castable alloys, utilizes a special lightweight shell mould, made by dipping a wax pattern repeatedly into a ceramic slurry until it is built up, and then firing it to remove the wax and, at the same time, to strengthen the shell. Quite apart from the advantage of producing much heavier castings than have hitherto been possible, the new ceramic-shell process can produce shapes which cannot be made by any other methods, as well as parts with more intricate coring. In addition, the castings have a fine grain structure, and less finishing is required than with conventional solid-mould castings.

* * *

Intended for welding high-alloy steel components, such as those required for turbines and other high-temperature applications, an **argon-shielded twin-arc welding process** is described in the Russian journal *Svarochnoye Proizvodstvo* for November 1960. In this process, one arc is struck between two non-consumable tungsten electrodes located a short distance above the welding zone, while the second arc is struck

So as to give an



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between a vibrating welding wire and one of the tungsten electrodes in the welding zone itself. The entire operation is carried out under a protective atmosphere of argon, current being supplied for the excitation of the arc between the two tungsten electrodes from a transformer and for the second arc from a d.c. welding generator. It is stated that the use of a vibrating welding wire improves metal flow and hence wetting, and, in conjunction with the other arc, produces a welding rate which is approximately twice as high as that obtainable by conventional arc welding.

* * *

As easy to process as most Class A and Class B varnishes, a **new Class H silicone varnish** which cures at 150°C in only 6 hr has been announced by the Dow Corning Corporation, of Midland, Mich. It is stated that, despite the lower curing temperature (about 50°C lower than that required for most other silicone varnishes), the new dipping and impregnating varnish has the highest heat stability of any other varnish known. Run-off is also substantially lower than that of other varnishes, ensuring appreciable savings in reduced waste, equipment maintenance, and clean-up time. The varnish is especially suitable for impregnating large electrical equipment, such as 500-kVA transformers, traction-motor armatures, motors, and generators, and also provides complete impregnation for the fine magnet-wire coils of electronic transformers and servo-motors, as well as permitting the construction of smaller, lighter, and more reliable units by virtue of its high thermal stability.

* * *

It is stated (*Product Engineering*, October 24, 1960) that so remarkable is the **similarity of the corrosion resistance of tantalum and glass** that tantalum can actually be used to patch glass equipment. Tantalum is inert to most acidic solutions, chromium-plating solutions, most salts, and many liquid metals. However, tests show that it is not very resistant to alkalis, except in low concentrations, and is attacked by most gases at 600°F and above. It is also subject to hydrogen embrittlement and, even at room temperature, atomic hydrogen liberated by the corrosion of an anodic material is readily absorbed. For this reason, it is stated that care should be taken not to couple tantalum to any other metal.

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BUSINESS NOTES

Elliott-Automation Ltd., of London, W.1, announce that their Swiss subsidiary, **Elliott-Automation A.G.**, has moved into larger offices at 32 Holbeinstrasse, Zurich (Tel: 47 05 70).

* * *

The **Electric Resistance Furnace Co. Ltd.**, of Weybridge, Surrey, a member of the **EFCO Group** of companies, has changed its name to **EFCO Furnaces Ltd.** This change has resulted from the increasing scope of the company's interests, which were originally confined to electric resistance heating, but have since been widened to include both gas- and oil-fired furnaces.

* * *

It is announced by **The Morgan Crucible Co. Ltd.** and **British Belting and Asbestos Ltd.** that a new company, designated **Morgan-Mintex Ltd.**, has been formed for the manufacture of sintered friction materials, to be sold under the registered trade-mark of "Sinterlink". These materials have been developed by The Morgan Crucible Co. Ltd. and are produced at their factory in Wandsworth, London, S.W.18, where the new company will be located. World sales will be handled by the Mintex Division of British Belting and Asbestos Ltd., who are sole concessionaires.

* * *

It is announced by **Forth Chemicals Ltd.** that a new styrene-monomer plant, with a capacity of 50,000 tons per year, is to be built between Neath and Port Talbot, South Wales, at a cost of over £3,000,000. Forth Chemicals Ltd. is two-thirds owned by **British Hydrocarbon Chemicals Ltd.** (which is jointly owned by **The British Petroleum Company Ltd.**, and **The Distillers Company**) and one-third by **Monsanto Chemicals Ltd.** The new plant will be located next to the site selected by British Hydrocarbon Chemicals for their recently announced expansion plans, near to the Llandarcy refinery of British Petroleum. The design and engineering of the new Forth plant, which is expected to come into operation in about two years, will be carried out by Monsanto Chemicals. Forth Chemicals Ltd. is the largest British manufacturer of styrene monomer.

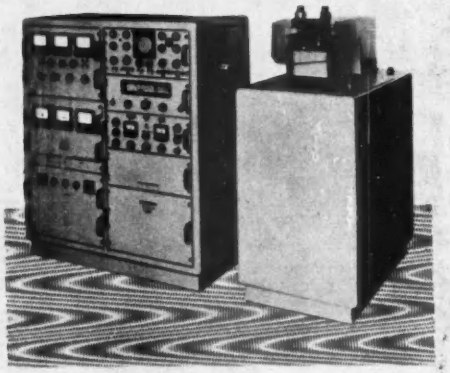
* * *

An agreement has been concluded between **Mannesmann-Meer A.G.**, of München-Gladbach, Germany, and **The Loewy Engineering Company Ltd.**, of Bournemouth, covering the supply and installation throughout the world of plant for the production of seamless tubes of carbon steels and low-alloy steels.

* * *

The **Hawker Siddeley Nuclear Power Co. Ltd.**, a member of the **Hawker Siddeley Group**, and **Spembly Ltd.**, a member of the **Harper Group**, have agreed to co-operate in the design, manufacture, and sale of specialized high-temperature furnaces. The main purpose of this agreement is for the joint exploitation of large high-temperature furnaces (four times larger than anything of their type at present available elsewhere in

TURBO 4



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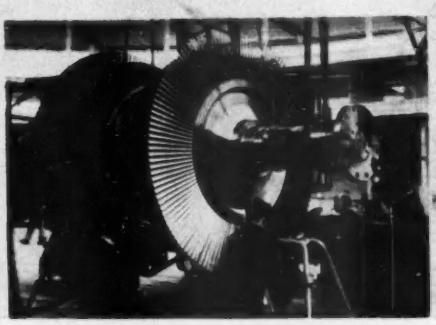

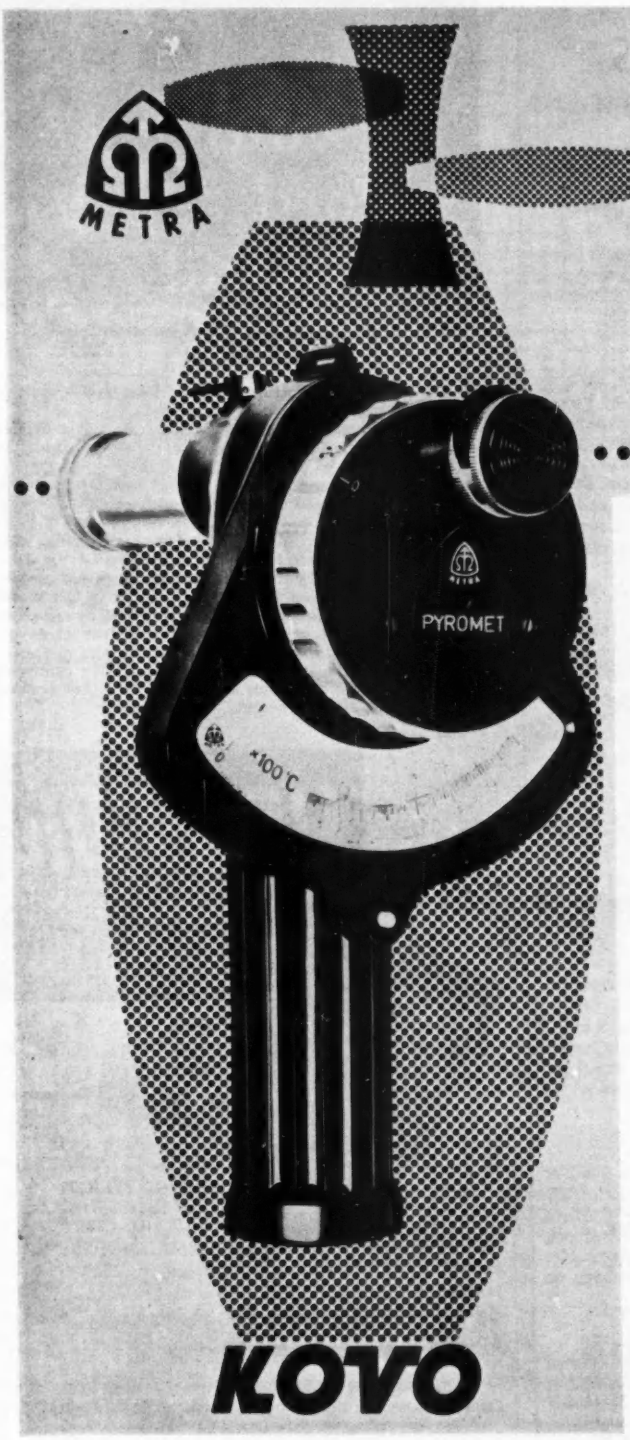

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BUSINESS NOTES

the world) designed and now being commissioned by Spembly Ltd. at the Hawker Siddeley Nuclear Power Co. Ltd. works at Langley.

* * *

The factory and offices of **Northern Scientific Equipment Ltd.** have now been moved to new premises at Bridge Road Works, Lymington, Hants. (Tel: Lymington 3288 (PBX)).

* * *

It is announced by **Ferodo Ltd.** that they are abou to complete the purchase of a 50-acre site at Parciau Farm, Griffith's Crossing, 2 miles from Caernarvon and 7 miles from Bangor, on the banks of the Menai Strait, for the erection of their new friction-materials factory. The first stage of the factory will have an area of 240,000 sq ft, with an adjacent canteen and service-block. Initially, the factory is expected to provide employment for 500 personnel, but ultimately the figure may rise to 1000.

* * *

The purchase of **W. J. Mariner and Co. Ltd.,** non-ferrous founders of Luton, Beds., is announced by **Opperman Gears (Holdings) Ltd.,** of Newbury, Berks. Mr. E. R. Opperman is now the chairman of W. J. Mariner and Co. Ltd., and Mr. J. A. Mariner, the son of the founder, continues as managing director. Also on the board are Messrs. W. B. McCurd and P. S. Lane.

* * *

Islands-Overseas Ltd., of Broadgate House, Coventry, and Marlon House, Mark Lane, London, E.C.3, have been appointed sole distributors in the U.K. for the sale of the range of "BEL" grinding-machine-tool coolant filters manufactured by **Braithwaite Equipment Ltd.,** of Luton, Beds.

* * *

Following the change of name of the parent company from **C. C. Wakefield & Co. Ltd.** to **Castrol Ltd.** in August 1960, **Wakefield-Dick Industrial Oils Ltd.,** a member of the **Castrol Group,** has now been renamed **Castrol Industrial Ltd.** This Company is the U.K. marketing organization of the Castrol Group for industrial, marine, and electrical oils.

* * *

A new company, **Ringway Machine Tools Ltd.,** of De: nsgate, Manchester 3, has been formed to handle exclusively in the U.K. all products made by **Heid,** of Vienna, Austria, including their universal and copying lathes, "Tastomatic" electric profiling systems for vertical boring and turning mills, and electromagnetic multi-disc clutches and planer drives.

* * *

The **Mortimer Machine Tool Co. Ltd.** has been formed as the parent company of the **Mortimer Engineering Co. Ltd.,** with head offices and showrooms at Mortimer House, Acton Lane, London, N.W.10. The executive directors are Mr. E. W. Kelleher and Mr. F. E. Wilson.

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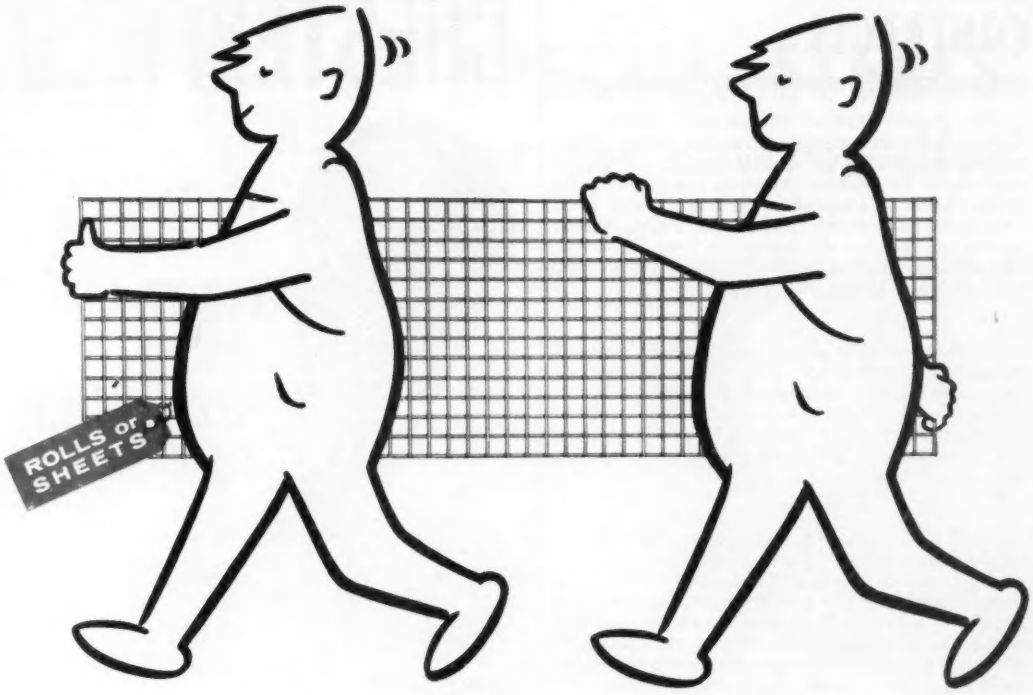

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CONTRACTS

The Powell Duffryn Engineering Company, of Cardiff, has been awarded a contract valued at approximately £90,000 for the construction of 50 rail tank-wagons for the Esso Petroleum Company. These 35-ton wagons are intended for the conveyance of Class "A" liquids and are fully fitted for fast traffic. Special features are that they will incorporate a scroll-iron type of suspension and, in addition to the conventional syphon pipe, a bottom charge and discharge.

* * *

An order, valued at over £300,000, has been entrusted to The General Electric Co. Ltd. by the Central Electricity Generating Board for switchgear to be installed at an outdoor substation at Corby, Northants. The plant supplied includes thirteen 132-kV, 3500-MA oil circuit-breakers, a 17-panel control board, relay panels, d.c. boards, and outdoor isolators.

* * *

The Loewy Engineering Company, of Bournemouth, have received through Mannesmann Export G.m.b.H. an order, valued at over £250,000, for the supply of a mains-frequency induction-heating installation for steel billets, to be installed at Mannesmann A.G., Roehrenwerk, Remscheid, Germany. This billet-heating equipment, which will be used in conjunction with a Loewy 3100-ton hydraulic extrusion press, has a nominal capacity of 21 tons per hour, with provision made to increase this output at a later stage to 28 tons per hour. The installation has a power rating of more than 10 MW and is the largest inducting-heating installation of its kind in the world.

* * *

A contract for 6½ miles of specially designed conveyor belting for the U.S.S.R. has been obtained by the Belting Division of the Dunlop Rubber Co. Ltd. The belting, which is to be used for carrying heavy ores, has a very high tensile strength and is more than 78 in. in width and over 1 in. in thickness, the largest individual belt weighing about 10½ tons. The duck for the belting will be made from 100% synthetic fibres, woven at the Dunlop Cotton Mills in Rochdale, while the conveyor belting itself will be manufactured at the Belting Division's plant on Merseyside.

* * *

The Air Ministry has recently awarded a contract to Petbow Ltd., of Sandwich, Kent, for the supply and installation of eight 200-kVA stand-by mains-failure generating sets for their "Ace-High" project. Each set is completely self-contained and arranged to operate independently, one acting as a stand-by to the other, and is capable of starting and accepting full load in less than 15 sec in an ambient temperature of −5°C, in the event of mains failure. These sets comprise Rolls-Royce Type-C8TFL eight-cylinder, turbo-charged diesel engines developing 268 bhp at 1500 rpm, flexibly coupled to Macfarlane transistorized 380/220-V, 3-phase, 50-cps alternators with an output of 200 kVA at a power factor of 0·85.

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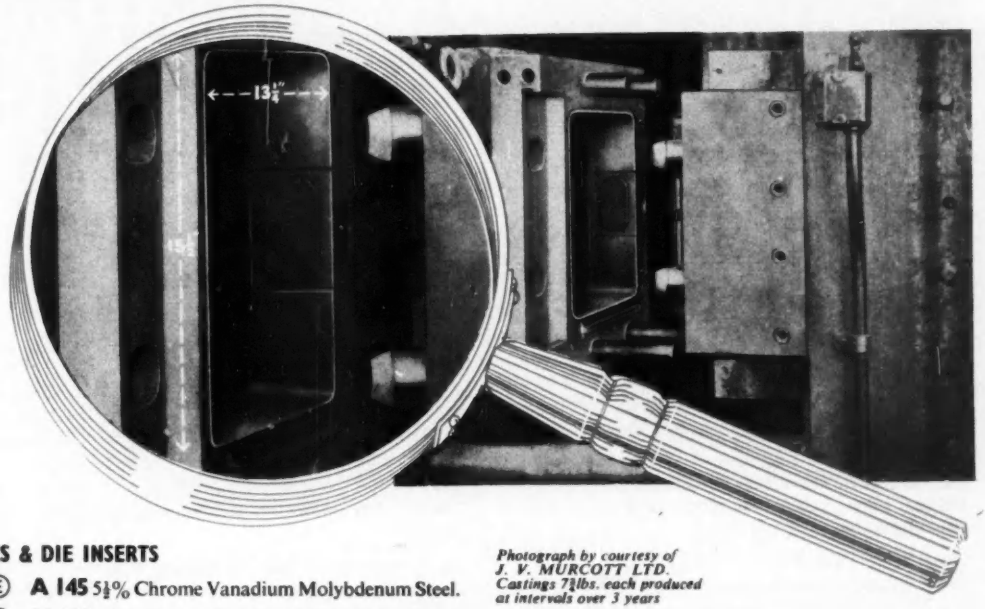

Photograph by courtesy of J. V. MURCOTT LTD. Castings 7¾lbs. each produced at intervals over 3 years

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(KE) **X 369** 5½% Chrome Tungsten Molybdenum Steel.

(KE) **896** Medium Carbon Chrome Vanadium Steel.

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PERSONAL

As announced by The Braby of Britain Group, **Air-Commodore J. Warburton,** a director of Auto-Diesels Ltd., has been elected to the board of Frederick Braby & Co. Ltd., both these companies being members of the group. Air-Commodore Warburton is in charge of the newly formed Aircraft Equipment Division at Braby House, London, E.C.1.

* * *

Mr. D. Bowen, formerly Midland Area manager for E. H. Jones Machine Tools Ltd., has been appointed sales director of Stanley Howard Ltd., of Saltley, Birmingham 7.

* * *

Following the retirement of **Mr. J. Abberley,** Firth Cleveland Tools Ltd. announce that **Mr. J. C. Abberley** has been appointed director in charge of their Tipton works, and **Mr. A. H. McIlreath** director in charge of the factories at Wolverhampton.

* * *

Mr. E. E. Jones, group commercial director of the Solartron Electronic Group Ltd., of Farnborough, Hants., is leaving to become managing director of Adrema (Holdings) Ltd., of London, W.3, and its subsidiaries, including the Bradma Companies. At the same time, he will become European vice-president of the Farringdon Manufacturing Company, of Needham Heights, Mass., U.S.A., the parent company of Adrema (Holdings) Ltd.

* * *

Consequent on the retirement of **Sir Samuel R. Beale, K.B.E., M.I.Mech.E.,** Worthington-Simpson Ltd., of Newark, announce that **Mr. P. B. H. Brown, M.I.Mech.E., M.Inst.R.,** has been appointed chairman of the company.

* * *

Mr. E. V. Beatson, of Joseph Lucas Ltd., has been appointed by the Council of the British Welding Research Association to serve on their research board, his particular fields of interest being resistance welding and brazing.

* * *

It is announced by The Wayne Kerr Laboratories Ltd., of Chessington, Surrey, that **Mr. B. Rogel, B.Sc. (Eng.), A.M.I.E.E.,** has left these laboratories to take up an appointment as managing director of a newly formed subsidiary of the Rosemount Engineering Company, of Minneapolis, Minn., U.S.A. He will, however, continue to act as consultant to Wayne Kerr, and in this capacity joins **Professor A. L. Cullen, O.B.E., Ph.D., M.I.E.E.,** Professor of Electrical Engineering at the University of Sheffield, and **Mr. V. S. Griffiths, Ph.D., F.R.I.C.,** Reader in Spectroscopy at the Battersea College of Technology.

* * *

Mr. A. S. D. Barrett, B.Sc.(Eng.), M.I.Mech.E., M.I.Chem.E., has been appointed consultant to Research and Control Instruments Ltd., of London, W.C.1,

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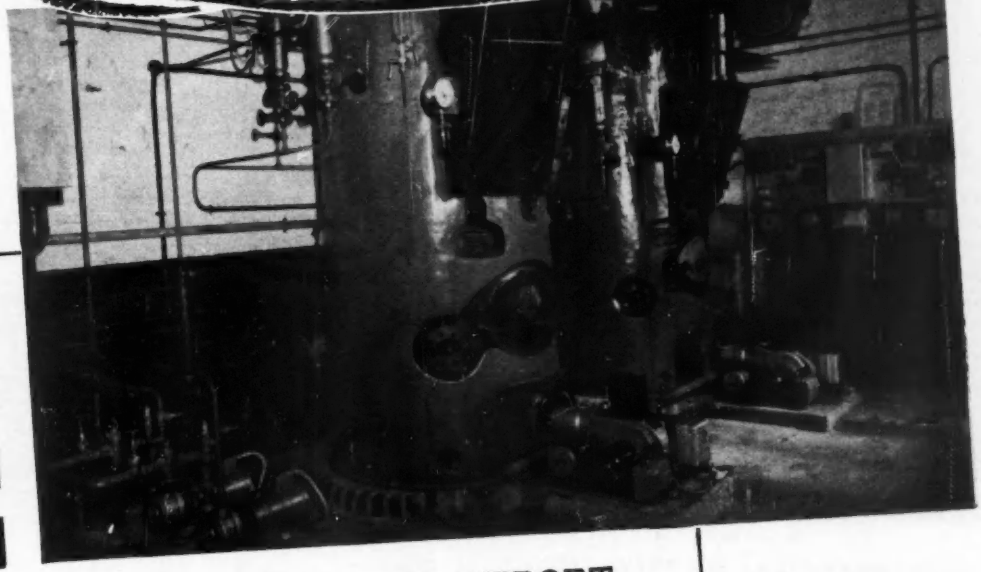

COMBUSTION TEST REPORT

Installation at:
Emeralda Limited,
The United Welsh Mills,
Marlborough Road,
CARDIFF.

Boilers: 2 Cochran Boilers rated at 750 and 900 lbs. steam/hour.
Burners: 2 Nu-way SBM.10.H/L burners.
Fuel: B.P. Britoleum. 200 secs.viscosity.

	No.1 Boiler	No.2 Boiler
HIGH FLAME		
CO_2 content flue gas Furnace:	15%	15·2%
Boiler Exit:	12%	12·5%
Flue Gas Temperature Boiler Exit:	565°F.	590°F.
Shell Smoke Number:	3.	4.
Boiler Efficiency (Gross C.V.)	77%	77%
LOW FLAME		
CO_2 content flue gas Furnace:	11·5%	11·25%
Boiler Exit:	9%	8·75%
Flue Gas Temperature Boiler Exit:	450°F.	480°F.
Shell Smoke Number:	3.	3.
Boiler Efficiency (Gross C.V.)	73·5%	72%

NOTE: The drop in CO_2 content between furnace and boiler exit indicates leaks causing ingress of air.

Photo by courtesy of Messrs. Emeralda Limited, Marlborough Road, Cardiff.

Heating installation by Messrs. Union Engineering Co. Ltd., Cardiff.

Test figures kindly supplied by a major Oil Company.

NU-WAY Oil-firing

NU-WAY HEATING PLANTS LIMITED, BOX (B 437). DROITWICH

"heart of the best heating systems"

PERSONAL

and has joined the board of directors. Mr. Barrett is a vice-chairman of the Scientific Instrument Research Association, secretary of the International Organization for Vacuum Science and Technology, and a founder member of the Company of Scientific Instrument Makers.

* * *

Following the retirement of **Mr. J. J. Gracie** on December 31, 1960, **Mr. T. H. Kelsey, M.A., M.I.E.E.,** becomes general manager of the engineering works of The General Electric Co. Ltd. at Witton, and **Mr. W. D. Morton, M.A., A.M.I.E.E., A.M.I.Mech.E.,** assistant general manager.

* * *

It is announced by Sandvik Steel Band Conveyors Ltd. that **Mr. V. C. Price** has been appointed managing director of the company in succession to **Mr. E. Bealing,** who will, however, remain on the board.

* * *

The United Steel Companies Ltd., of Sheffield 10, announce that **Mr. C. M. Slocombe** will be appointed director of engineering of the Distington Engineering Co. Ltd. from April 1, 1961, and will relinquish his present position of director of engineering at Samuel Fox and Co. Ltd. on August 31, 1961.

* * *

Sir Gordon Radley, K.C.B., C.B.E., Ph.D., M.I.E.E., has been elected a director of The English Electric Co. Ltd. In July, 1960, Sir Gordon joined the boards of Marconi's Wireless Telegraph Co. Ltd., Marconi Instruments Ltd., The English Electric Valve Co. Ltd., and the Marconi International Marine Communication Co. Ltd., all members of The English Electric Group, where he is concerned with the development of telecommunication equipment for world markets.

* * *

Newall Group Sales Ltd., of Peterborough, announce that **Mr. W. K. Temple, A.M.I.Mech.E.,** chief engineer of the Newall organization, has been appointed a director of The Newall Engineering Co. Ltd. Mr. Temple, who is intimately connected with many of the company's technical developments in the field of machine-tool manufacture, will retain his existing office and responsibility for direction of the Group's technical affairs.

* * *

Following recent alteration of the company's Articles of Association, authorizing the appointment of sectional directors, Crofts (Engineers) Ltd., of Bradford 3, Yorks., announce that four executives of the company have now been appointed with this category, these being **Mr. E. J. Holdin,** home sales director (previously general sales manager); **Mr. F. Rotheray,** overseas sales director (previously overseas sales manager); **Mr. H. W. Cameron,** London area director (previously London area manager); and **Mr. A. Spencer,** commercial director (previously commercial manager).

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- Surface hardness up to 1100 D.P.H.
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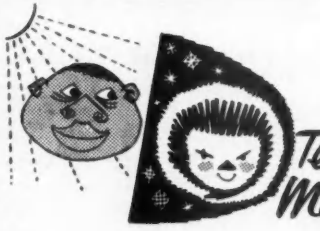

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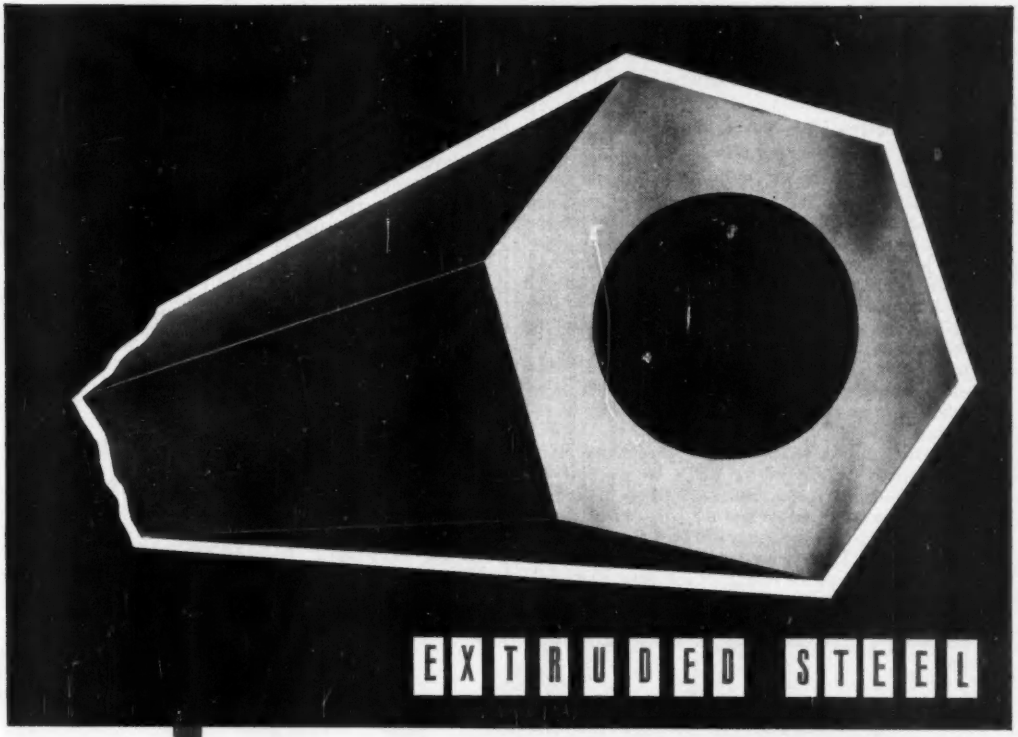

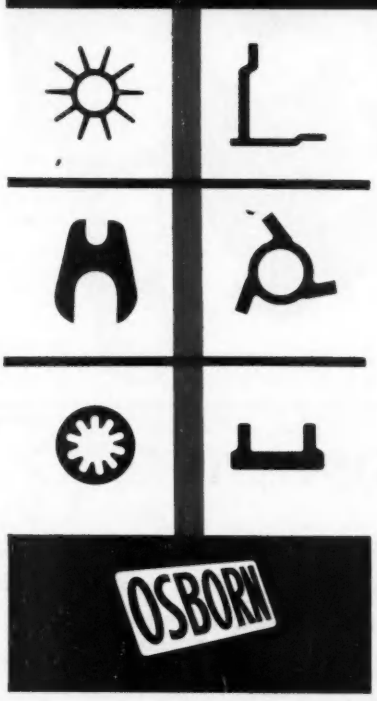

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NEWS ROUND-UP

Self-Contained Sea-Water Evaporator for Drinking Water

Pioneers of the vacuum-flash evaporator in Great Britain, Richardson, Westgarth & Co. Ltd., have just despatched to the Sheikdom of Abu Dahbi, on the Trucial Coast, a fully self-contained sea-water evaporator for the production of 14,400 gal of drinking-water per day. In this plant, which is believed to be the first of its kind, the unusual feature of the evaporator is that it has been designed to float on its own pontoon. In this connection, it should be appreciated that there are no port facilities at Abu Dahbi, so that the plant, after travelling from the Tyne as deck cargo, will be lowered into the sea some miles from the coast and then towed to the beach.

With the aid of a winch, forming part of the plant, the unit will be hauled up the beach onto a concrete foundation, all that is then necessary being to connect up to a fuel supply and to run sea-water pipes to the plant, after which the evaporator will be ready to produce drinking-water. The pontoon remains as part of the plant and will be used for storage of the water produced. In addition, the plant can be arranged to produce electrical power for driving ancillary equipment, such as fuel pumps, sea-water pumps, and brine-circulating pumps.

New Engineering Building at the Imperial College of Science and Technology

The first part of the new engineering building at the Imperial College of Science and Technology in Exhibition Road, London, has now been fully commissioned. The complete building, which should be ready in three or four years, will take the place of the old buildings, and the latter will be progressively demolished to make room for it. The building will be 440 ft in length and on nine floor levels, and will provide teaching and research facilities for more than 350 students of mechanical engineering and for some 300 of the engineering students from other departments of the college.

As well as major groups working on applied thermodynamics and applied mechanics, stress analysis, etc., the department also includes sections for studying nuclear power and production engineering. The building will form the eastern boundary of a new east quadrangle, bounded on the south and west by other new buildings under construction for civil and electrical engineering.

Symposium on Welding in Shipbuilding

The Royal Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders have agreed to co-operate with the Institute of Welding in a joint Symposium on Welding in Shipbuilding, to be held in London in October/November, 1961. The joint committee therefore invites offers of papers, preferably of between 2000 and 3000 words, on a number of subjects, i.e., the structural design of welded hulls, the building of welded ships, standard layout for welded shipbuilding, automatic welding in shipbuilding,

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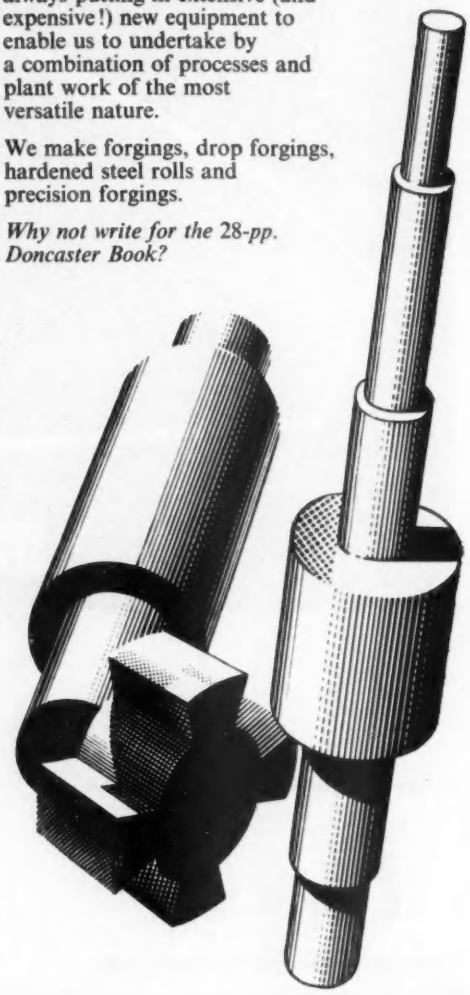

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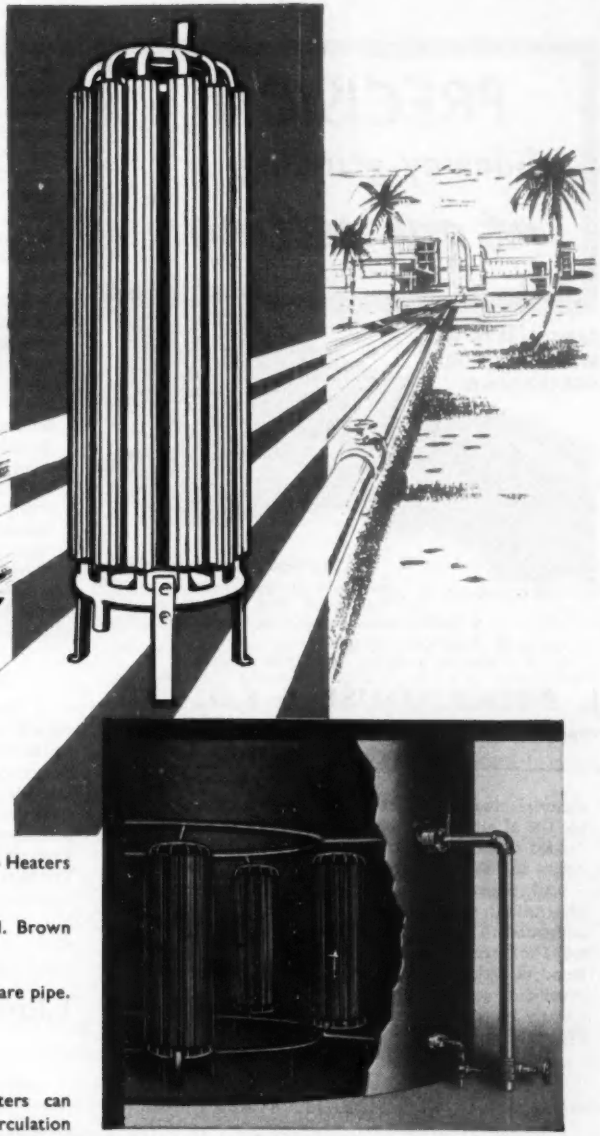

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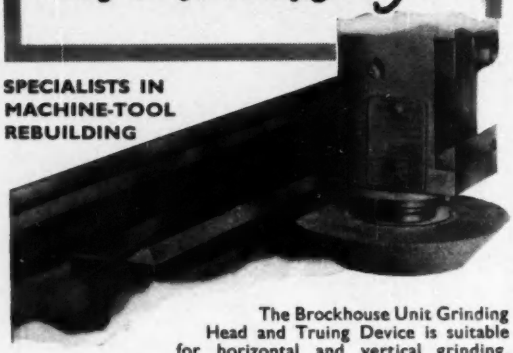

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materials handling, welded joints in thick mild steel, the use of aluminium alloys or high-yield-point steels in welded ship construction, non-destructive testing of ship welds, and the training and testing of ship welders.

All papers, the MSS of which, complete with illustrations, will be required by April 1, 1961, should be addressed to The Secretary, Joint Symposium Committee, The Institute of Welding, 54 Princes Gate, Exhibition Road, London, S.W.7. All papers accepted by the organizing committee will be preprinted and will subsequently be published with a Discussion in a volume of Proceedings.

The British Institution of Radio Engineers Convention

Scheduled to take place at Oxford University between July 5 and 9, the 1961 Convention of The British Institution of Radio Engineers will have as its theme "Radio Techniques and Space Research" and will contain at least six sessions, the scope of which provisionally covers the following:—

Session No. 1: "Review of the Role of Radio Technique in Space Research", comprising survey papers on the ionosphere, instruments in satellites, deep-space aspects, and terrestrial communications.

Session No. 2: "Satellite Engineering Problems", covering papers on environmental aspects, constructional techniques, component and system reliability, power supplies, etc.

Session No. 3: "Extra-Terrestrial Measurements", dealing with papers on such subjects as the measurement of ionic density and upper-atmosphere composition, geomagnetic-field determinations, Faraday rotation, and cosmic-ray investigations.

Session No. 4: "Telemetry", consisting of papers on coding, bandwidth considerations, frequency allocations, satellite and launcher control, etc.

Session No. 5: "Techniques in Radio-Astronomy", involving papers concerned with various types of aerials, low-noise radio receivers, the radio aspects of the computational techniques employed, etc.

Session No. 6: "Satellites in Terrestrial Communications", covering papers on the systems and circuit-engineering aspects of passive and active satellite repeaters and their associated ground receiving stations.

The Convention Committee invites offers of papers, and these, accompanied in the first instance by a synopsis, should be addressed to The British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1.

Plastics Exhibition and Symposium

A Plastics Exhibition and Symposium will be held at the Grand Hotel, Sheffield, on February 21 and 22, 1961, by BX Plastics Ltd. A programme of papers on packaging, design trends, and technical and other uses of plastics will take place against a background of plastics materials and their products and there will be three sessions per day, commencing at 10.30 a.m., 2.15 p.m., and 6.00 p.m Free admission tickes are available on application to the Publicity Department, BX Plastics Ltd., Chingford, London, E.4.

Classified Advertisements

The rate for all classified advertisements is 9d. per word: in bold print 1s. per word: minimum order 10s. Box-number advertisements 1s. extra. Semi-displayed advertisements on this page 60s. per single column inch. Instructions, together with remittance, must be received not later than the 1st of each month for advertisements to appear in the same month's issue.

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Applicants should have a 1st or 2nd Class Honours Degree of a British University. Relevant experience is not necessary although a period of research work either at a University or in industry would be an advantage.

Initially, salary will depend on age, experience and qualifications and there is adequate scope for progressive remuneration. There is a Staff Pension Fund and an Employee Profit-Sharing Scheme. Assistance can be given towards house purchase and removal expenses for married men.

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NEW TECHNICAL BOOKS

Engineering Management. 2nd edition, 1960. By Struan A. Robertson, B.Sc.(Eng.), B.Com., Wh.Ex., A.M.I.C.E., M.I.Mech.E. 480 pp., 12 illustrations. Publishers: Blackie & Son Ltd., 17 Stanhope Street, Glasgow, C.4. Price: 30/–.

For some students, the study of engineering management, i.e., the art of creating industrial relations in order to secure co-operation, is an accessory to the study of engineering design. Many of the problems encountered in the design of machines or structures are, in fact, management problems in connection with production planning, estimating, economic utilization of resources, methods of inspection, and so on. There can be no doubt, therefore, that a knowledge of the management is valuable, inasmuch as it enables designers to understand the setting in which they work and in which their designs will later be carried out. This book consequently fills a definite need, dealing, as it does, with the art, science, and practice of engineering management.

In this second edition, various alterations have been made, these being mainly engendered by the changes in industrial conditions that have taken place since the publication of the first edition in 1948. The text itself is founded on lectures given to University, Higher National Certificate, and Diploma in Technology engineering students, and also to others studying for the examination of the Institution of Mechanical Engineers in Industrial Administration.

Electronic Equipment Reliability. By G. W. A. Dummer, M.B.E., M.I.E.E., Sen.Mem.I.R.E., and N. Griffin, A.M.Brit.I.R.E. 286 pp., 88 illustrations. Publishers: Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price: 45/–.

The increasing complexity of modern electronic systems results from changes in the application of electronic devices to wider fields, where the emphasis is on greater accuracy and more precise performance, with correspondingly higher orders of all-round reliability. It is true, of course, that considerable literature exists on the subject of reliability, but, as the authors point out in their preface, this book has involved much sorting and classifying of material, thereby facilitating study of the subject by presenting what is in effect a summary of present knowledge, in order to assist designers and users to obtain maximum reliability in their equipment.

The authors, both of whom are members of the Royal Radar Establishment, are in a unique position for amassing the data on which this book is based, and they have succeeded admirably in presenting the most important aspects of reliability in electronic equipment clearly and concisely. As such, this book is definitely an important contribution to practical literature on electronic equipment.

Proceedings of the National Clean-Air Conference, 1959. 276 pp., 150 illustrations. Published by the National Society for Clean Air, Field House, Breams Buildings, London, E.C.4. Price: 30/– (postage 2/6).

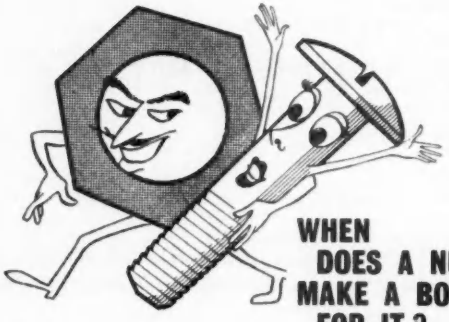
This interesting and well-produced volume contains the 78 papers presented at the International Clean Air Conference, which was held in London in October 1959 and which was organized by the National Society for Clean Air to celebrate the diamond jubilee of their foundation. The papers are conveniently grouped according to their subject, covering national air-pollution problems, legislation, education, etc.; technical considerations; observations, investigations, and measurement of air pollution; and research and international co-operation. In addition, as the papers in each session were reviewed by a rapporteur, these reviews, together with discussions and authors' replies, are also included in the book.

Each paper is by a recognized expert in his own particular field, the countries represented including, in addition to the U.K., Eire, Canada, South Africa, U.S.A., Japan, France, Belgium, Italy, Denmark, Norway, Sweden, Germany, Czechoslovakia, Poland, and Russia. The large number of papers, the varied aspects of air pollution that they cover, and the number of different countries represented by the contributors make this the widest and most international survey of the problem ever to be published.

Electronic Fundamentals and Applications. 2nd edition, 1960. By John D. Ryder. 734 pp., 517 illustrations. Publishers: Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price: 60/–.

First published in the U.S.A., this well-known textbook covers most of the work required by students in universities and technical colleges in connection with the fundamentals of electronics and the applications of electronic devices.

In this new edition, the author, who is Dean of Engineering and Professor of Electrical Engineering at Michigan State University, considers that the transistor and other semiconductor devices have now proved themselves. For this reason, he has consolidated the fundamental pheomena underlying both types of device into a joint treatment. He has also brought together electronics and basic network theory, and emphasises the standard methods that prevail, once an electronic device has been reduced to a linear active circuit. Professor Ryder writes well and simply, as well as authoritatively, and the result is a book which is not only eminently readable and interesting, but one which is also of great practical value to all those requiring an insight into the fundamentals of the subject.



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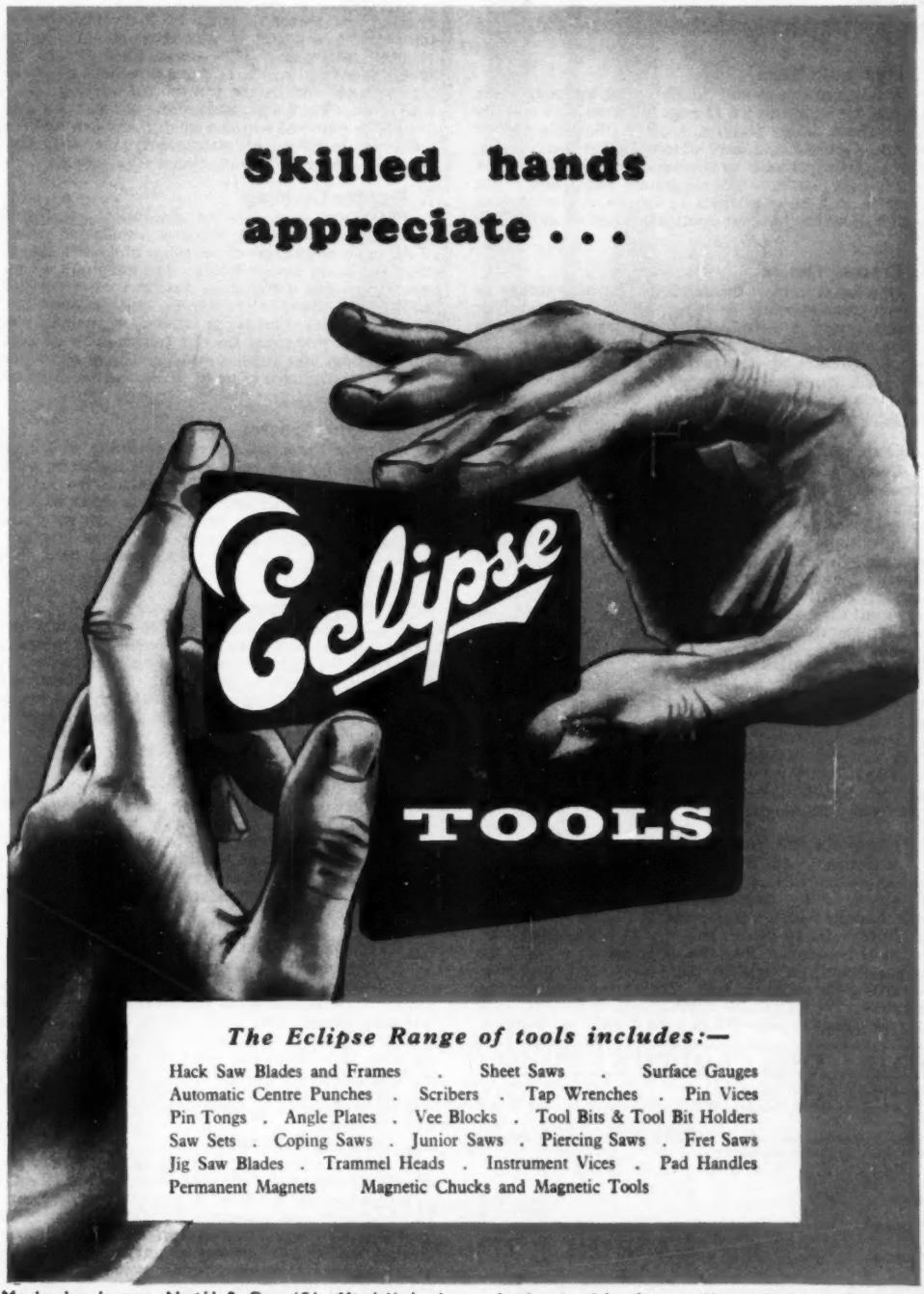
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2. Process Timers

Developed to meet the demand for a wide variety of contact requirements, a range of a.c.-motor driven process timers is introduced in a 6-page folder. The timers are self-resetting and can be started by a remote switch. Units comprising two or more process timers are also available, which are ganged together in such a way that each timer triggers the operation of the next, thus providing a completely automatic timing sequence.

3. Oil-Fired Boilers

Details are given in a 4-page leaflet of a range of horizontal oil-fired industrial and marine boilers of compact design and fully-automatic operation. The boilers have relatively small water content and, thus, their steam-raising cycle is comparatively short and the unit is much lighter than any other firetube boiler of similar capacity. The oil burners of the boilers give a radiant flame, permitting a high proportion of the heat to be taken out through the furnace walls and giving very low back-temperature.

4. Porous Plastics

Suitable for air and liquid filtration, for fluidizing powders with air, and for a number of other industrial applications, a porous plastics material is introduced in an 8-page brochure. The material, which is produced from high-density polythene and can withstand temperatures up to 212°F without distortion, is light and flexible, has considerable strength, and can easily be fabricated in tubes and other shapes.

5. Tee-Bolts and Socket Studs

A 6-page folder gives a description of a range of composite tee-bolts and socket studs manufactured from high-grade alloy steel and heat-treated to achieve exceptionally high tensile strength. The tee-bolts, which are suitable for all British and American machine tables, are more economical than the solid type of bolts, as it is only necessary to replace the socket stud instead of discarding the complete bolt. The socket studs are also recommended for various applications in the toolroom and for assembly work where long lengths are required.

6. Hydraulic Transmission Systems

Combining a variable-output pump and a fixed-displacement motor, a range of hydrostatic hydraulic transmission systems is described in an illustrated 16-page catalogue. The transmission system offers speed ratios from zero to 1 : 1 and provides a constant-hp performance, the torque transmitted varying inversely with speed. The components of the system can either be compactly mounted within a single container, which also forms the reservoir, or, alternatively, the units can be arranged separately to suit special requirements.

7. Flexible Couplings

High shock and vibration absorption, misalignment without wear, and quick and easy installation are some of the main advantages of the range of flexible couplings described in an 8-page folder. The couplings comprise two flanges and a two-piece flexible rubber sleeve, the teeth of the sleeve-halves locking into the teeth of the flanges without clamps or screws, tightening under torque, and providing smooth transmission of power. The couplings take angular misalignment of up to 1 deg., parallel misalignment of up to $\frac{1}{16}$ in., and end-float up to $\frac{1}{4}$ in.

8. Multiple V-Drives

Coupling the simplicity and flexibility of flat belts with the ability of V-belts to provide higher power and speed ratios, shorter centre distances, and freedom from slip, a range of multiple V-drives is dealt with in a 26-page brochure. The belts, which run in specially grooved pulleys, are recommended for use in place of single industrial belts, fhp belts, wedged belts in the automotive field, etc.

9. Electric Welding

Information is contained in a 56-page handbook on a wide range of electric welding processes and equipment, comprising welding sets, welding equipment and accessories, positioning in welding, etc. Chapters are included on the welding of creep-resisting, stainless, and high-tensile steels, as well as on surfacing, grooving, piercing, and trimming.

10. Piston Seals

Responsive to small pressure changes, free from mechanical spring gradient, and having extremely long flex life, a range of piston seals is described in an illustrated 8-page brochure. The seals, which are long-stroke, deep-convolution, constant-area diaphragms, are recommended for applications in pumps, compressors, thermostatic valves, pressure switches, self-resetting dashpots, etc.

11. Hydraulic Fluids and Lubricants

A 52-page catalogue serves as a useful guide on the multifarious uses of a range of hydraulic fluids and lubricants recommended as metal-working, heat-transfer, low-temperature, and brake fluids, high-temperature, gear, compressor, and engine lubricants, plasticizers, solvents, etc. The fluids show less change in viscosity with temperature-variation than do unmodified petroleum oils, have excellent chemical stability, are non-corrosive, and respond well to selective additives.

12. Welding Generators

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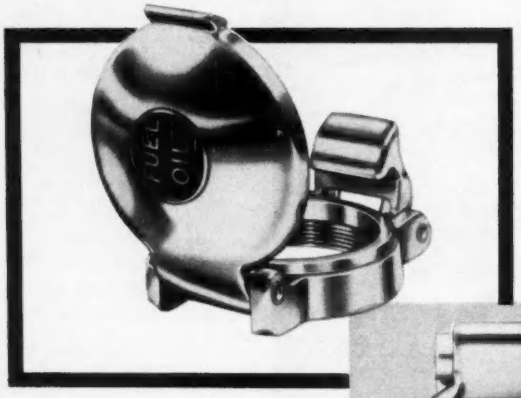

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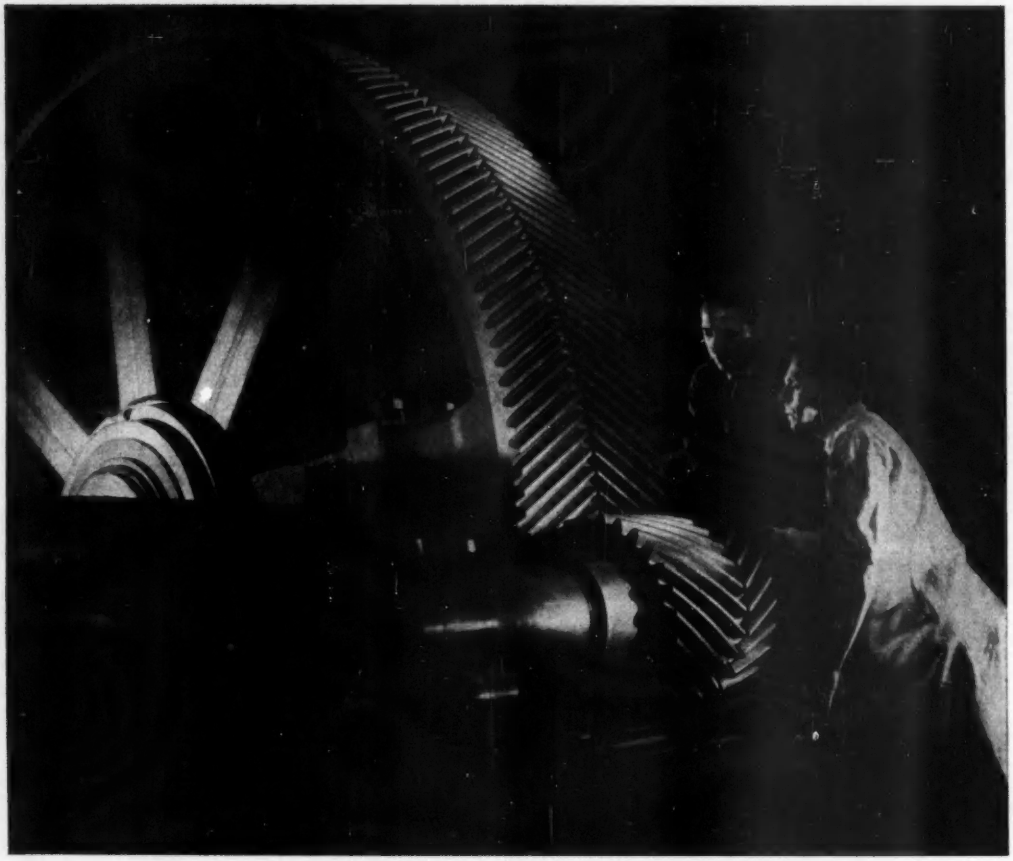

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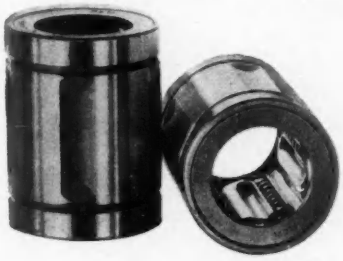

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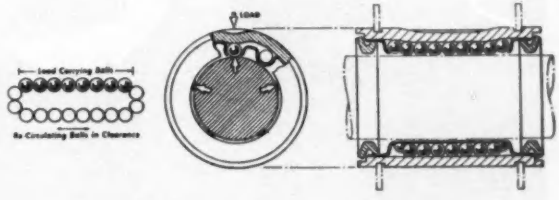

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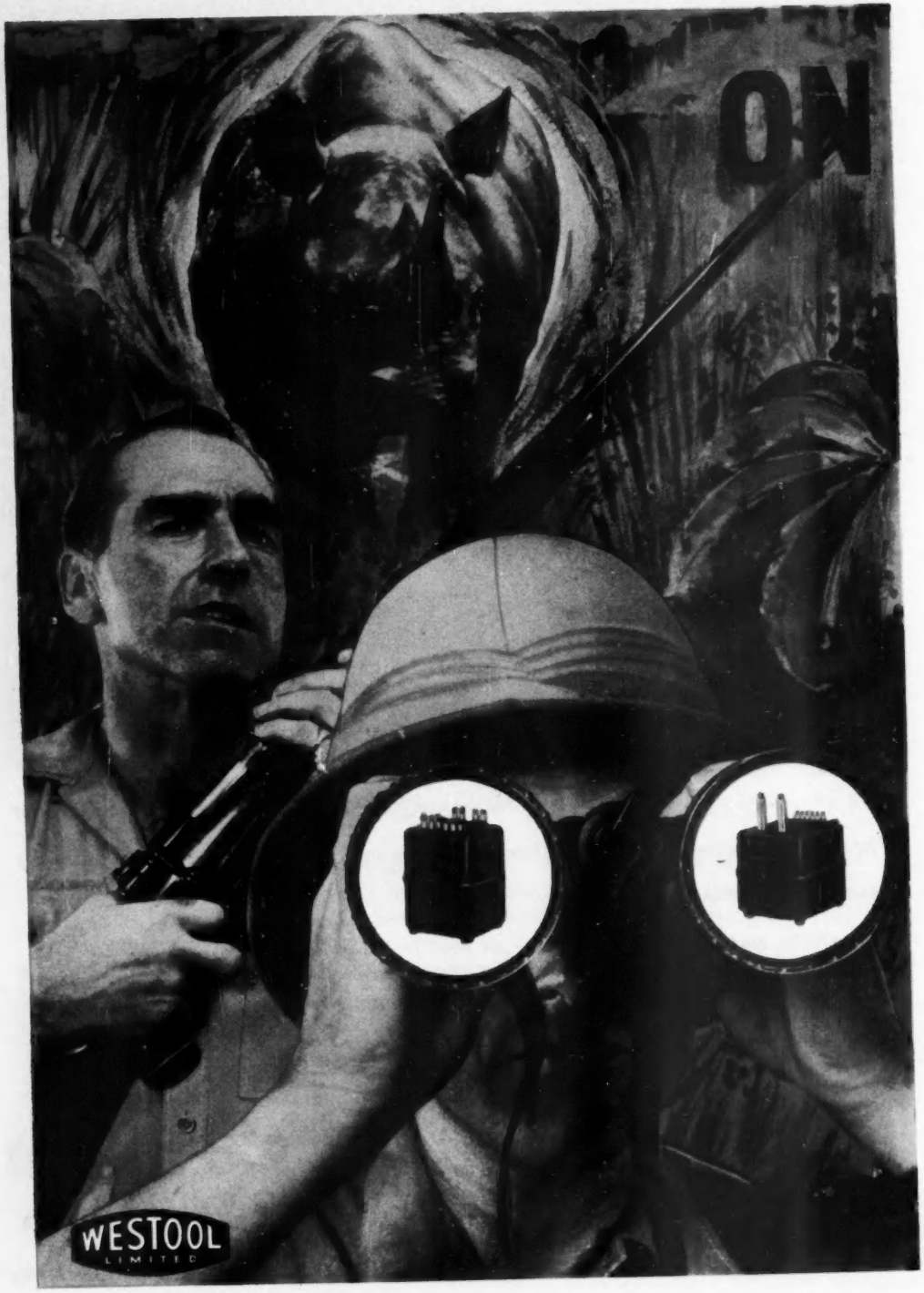
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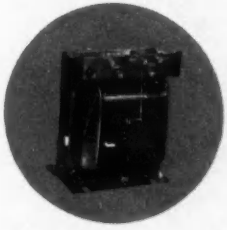
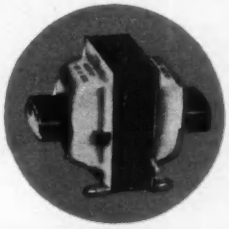
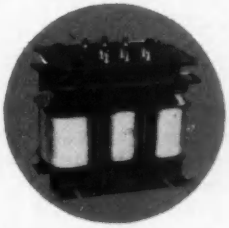

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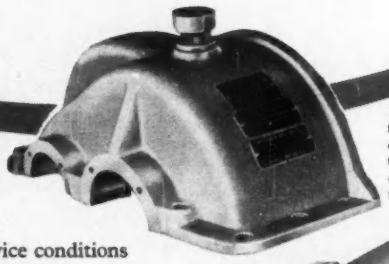

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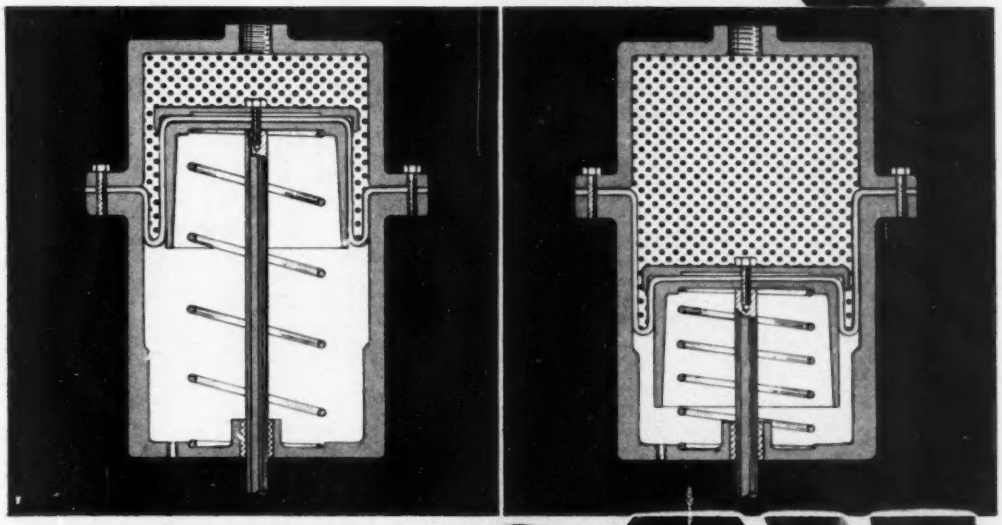

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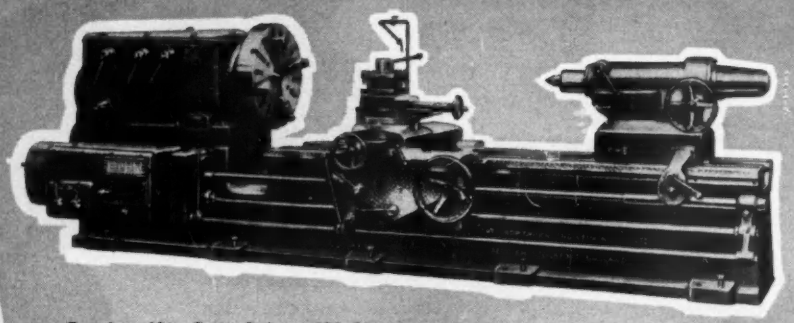

Crowthorn 18 in. Centre Lathe on 15 ft. 3 in. gap bed, admitting 8 ft. 0 in. between centres. Swing over bed 36¼ in. Swing in gap 57 in. × 21 in., hole through spindle 4¼ in. dia. 25 h.p. motor drive.

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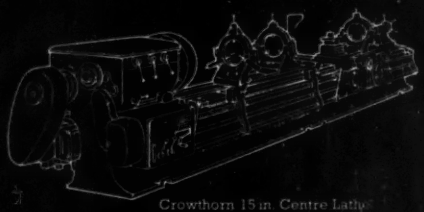

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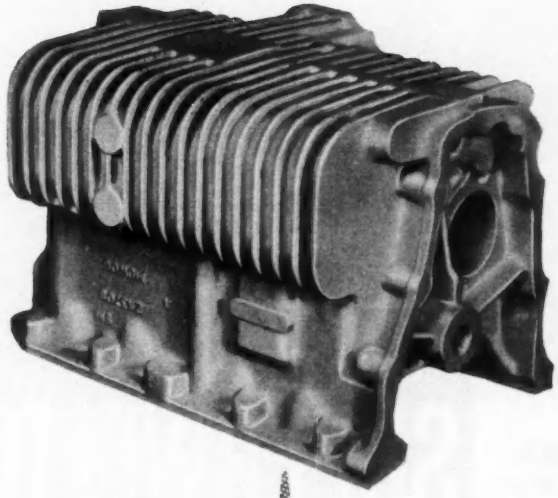

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Director

March 1960

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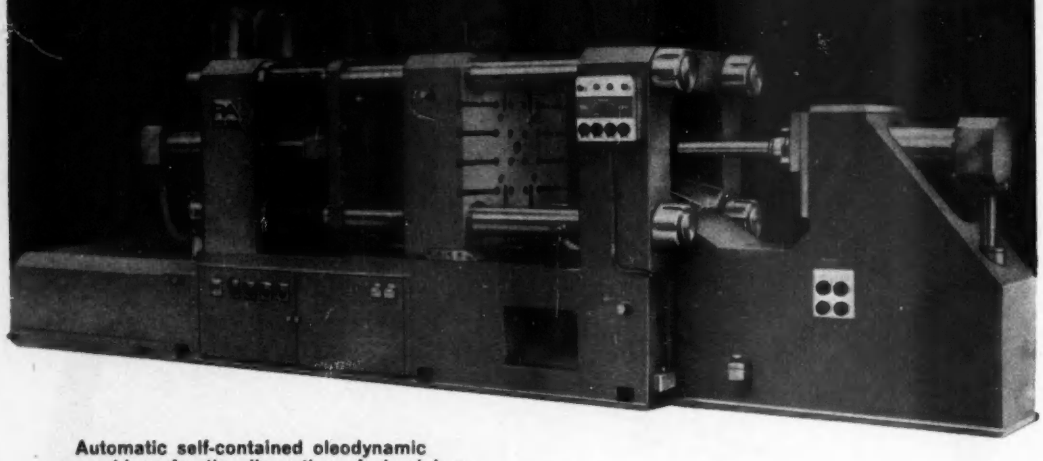
MODEL "OG 45" HORIZONTAL COLD CHAMBER
CLOSING POWER 450 t



Automatic self-contained oleodynamic machines for the diecasting of aluminium or alloy coppers, with horizontal cold chamber or vertical with warm chamber, under vacuum.

Models with an injection capacity from 2000 to 18.000 gr of aluminium and a closing power of 150 - 300 - 450 - 600 - 800 - 1000 tons.

Synchronized automatic cycle with radial lifting control on schedule.

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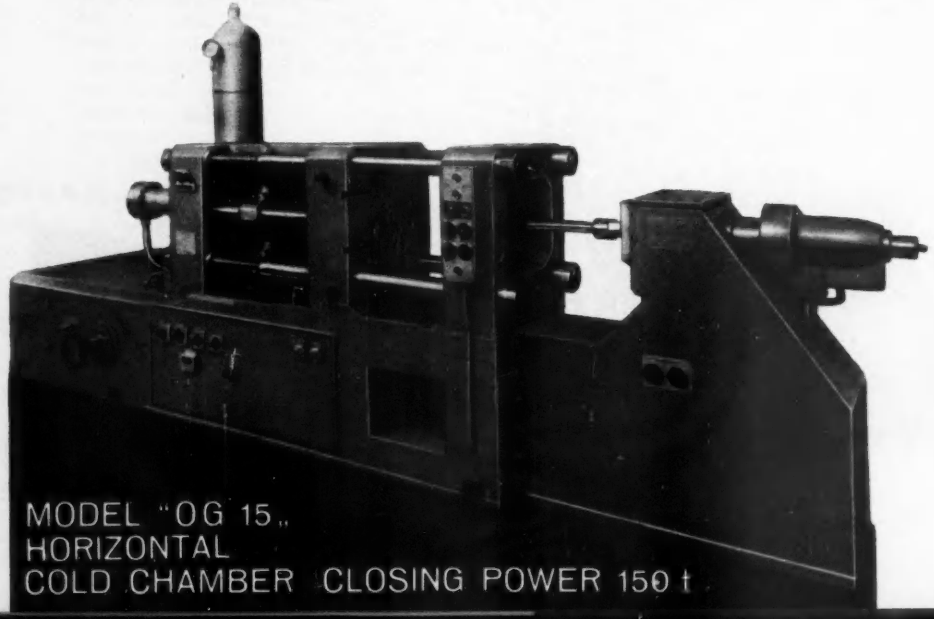

MODEL "OG 15"
HORIZONTAL
COLD CHAMBER CLOSING POWER 150 t

50 Years

1911 - 1961

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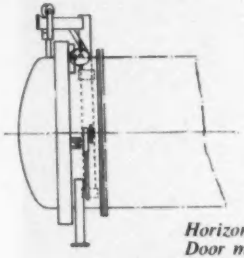
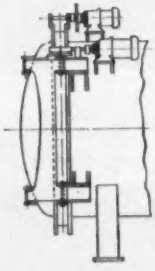
IVANHOE

RING CLAMP BOLTLESS DOORS

for vacuum and pressure vessels



Horizontal Vessel Door moved by side Davit.



Power Operated Boltless Door and Clamp ring.

Jenkins ring clamp boltless doors offer easy access to all types of pressure and vacuum vessels without impairing sealing efficiency for vessels requiring frequent opening. This brings about a considerable reduction in cost of labour and increases the speed of operation.

The ring clamp is so arranged that when it rotates, its mild steel clamp tongues engage with corresponding tongues in the door flange. The pressure load on the door is taken entirely by these steel clamps—while the sealing gasket ensures that a positive pressure seal is maintained. The door itself does not rotate so there is no wear on the sealing gasket. A safety locking arrangement provides protection against movement of the ring clamp while the vessel is under pressure.

The small movement of the ring clamp necessary to disengage the door can easily be accomplished by manual operation or by electric, hydraulic, or pneumatic power operation.

The Jenkins ring clamp boltless door is suitable for vertical or horizontally arranged vessels. Ring clamp boltless doors with a short extension shell and bolting flange are available for adapting existing bolted door vessels to this system.

Boltless doors are suitable for Kiers, Sterilizers, Vulcanizers, Impregnating Autoclaves and similar vessels.

The latest technical leaflet No. 6A gives full information and is available free on request.

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C59A/417

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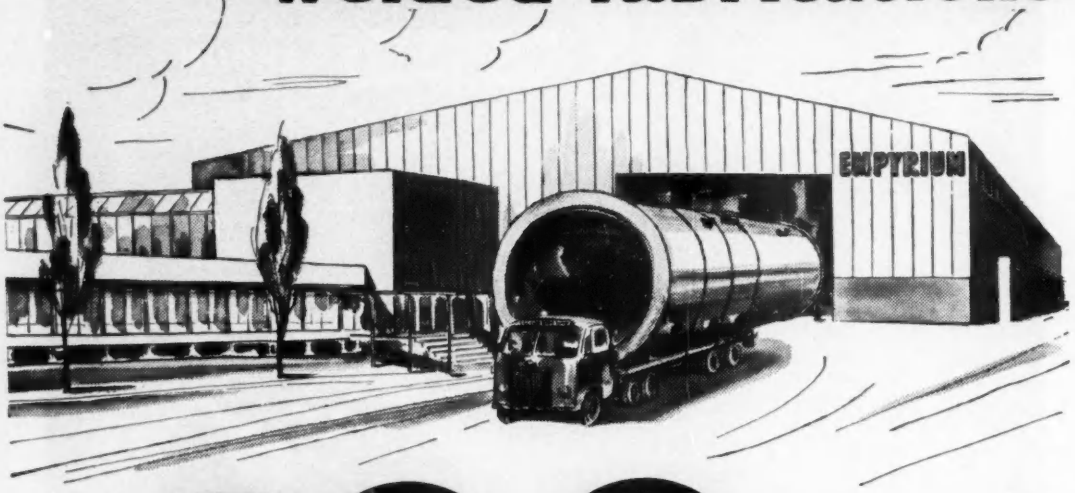

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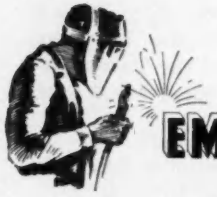

The illustration shows an artist's impression of our New Premises, the manufacturing part of which is now in full production.

For further information write to

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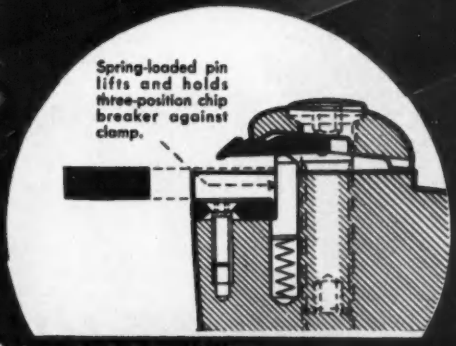

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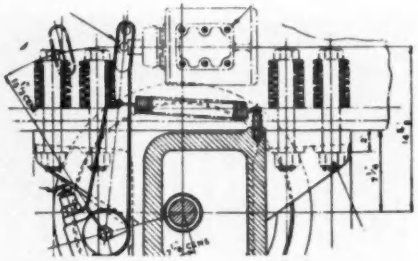
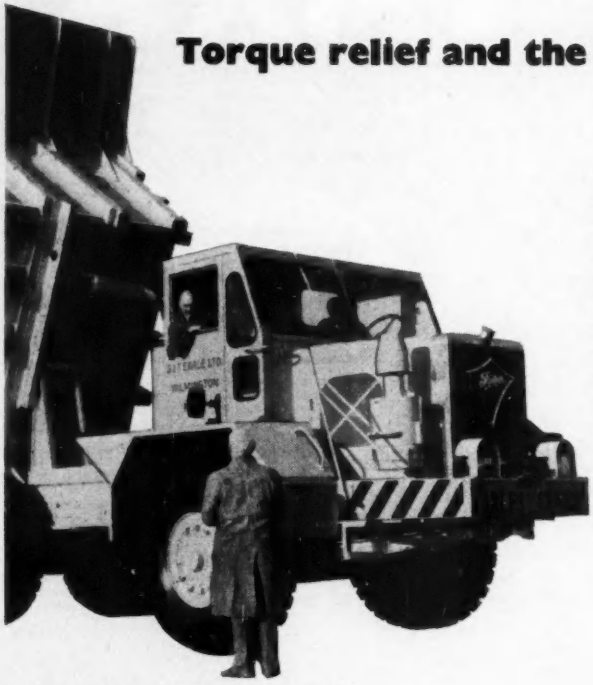


Torque relief and the Belleville Washer



Messrs. Fodens Ltd., fit Belleville washers in packs of 7 pairs on their F.R.6/45 Heavy Duty Dumper. This proved to be the most effective method of relieving twisting of the rear axle case produced by braking and transmission torques.

The potential uses of Belleville washers are endless.

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Salter technicians can help you. Their services are freely at your disposal.

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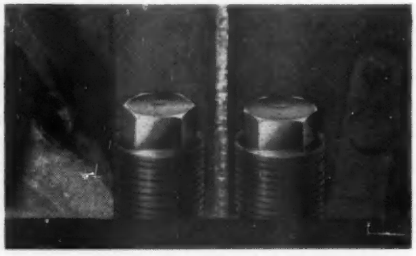

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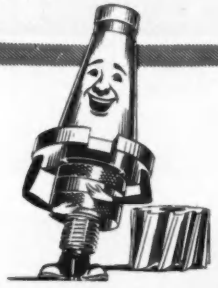
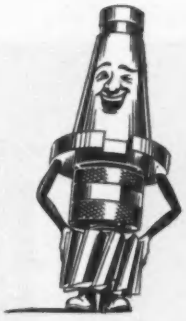
First Stage

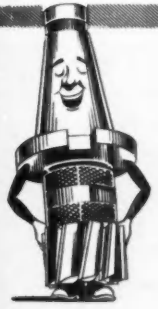
Screw on the nut by hand —as far as it will go.



Second Stage

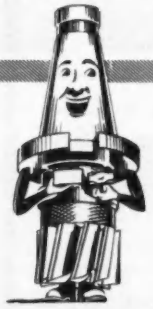
Screw on the cutter to meet the nut—then release by a part reverse turn.





Third Stage

Screw back the nut firmly against the cutter by hand—immediately cutting starts the cutter will lock solidly against the nut, making a rigid tool assembly.



To Release

Apply the spanner to the nut and a few sharp hammer blows will release the nut from the cutter, which can then be screwed off by hand."

You can't go wrong—send for the Heli-Matic brochure giving the full range of Arbors and Cutters.

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There are, in fact, a number of interesting talking points about the Sykes $3\frac{1}{4}''$ gear and lubricant testing machine. Its ancestor was a machine designed by Prof. H. Blok of Delft Laboratories about twenty-five years ago. Although the capacity of the original was eventually outgrown, its principles were still good, and a larger model followed. Early in the war, the Ministry of Aircraft Production needed similar machines—redesigned and built by Sykes in co-operation with the Institute of Automobile Engineering. Since then these machines have been doing important work for Government establishments, Research Institutes and Oil Companies in various parts of the world.

Later, from the fund of knowledge gained, and to meet the need for changed applications, Sykes produced a new and improved version which is widely used for such work as lubricant rating, checking gear performance with various types of steel; different profiles and variations of specific sliding, and for the testing of chemical treatments and metallic plating.

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2 holes	3⅝" dia.	1 hole	2¼" dia.
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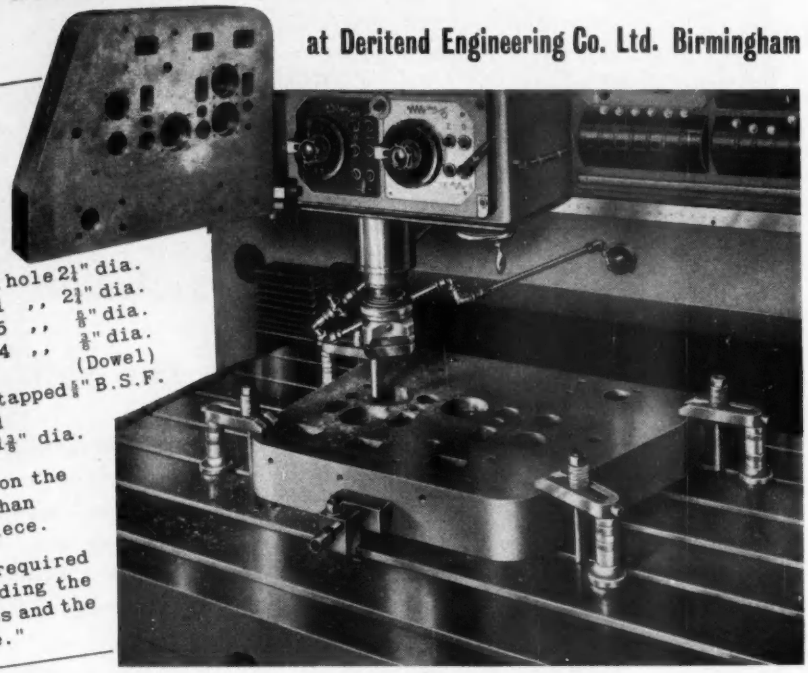
3 ,,	1¼" dia.	5 ,,	⅝" dia.
2 ,,	1⅛" dia.	4 ,,	⅜" dia. (Dowel)
2 ,,	1" dia.		
1 ,,	drilled and tapped ⅝" B.S.F.		
2 ,,	⅝" dia. and spot face 1⅝" dia.		

Machining time on the BEMAG is less than 3½ hours per piece.

Former method required 8¾ hours excluding the 5-⅝" dia. holes and the ⅝" tapped hole."



The BEMAG Co-ordinate Boring & Milling Machine for JIGLESS production represents a revolutionary approach to single, batch and mass production boring.

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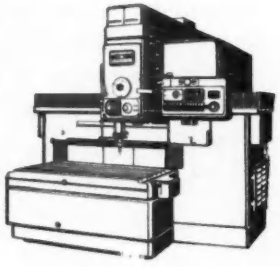

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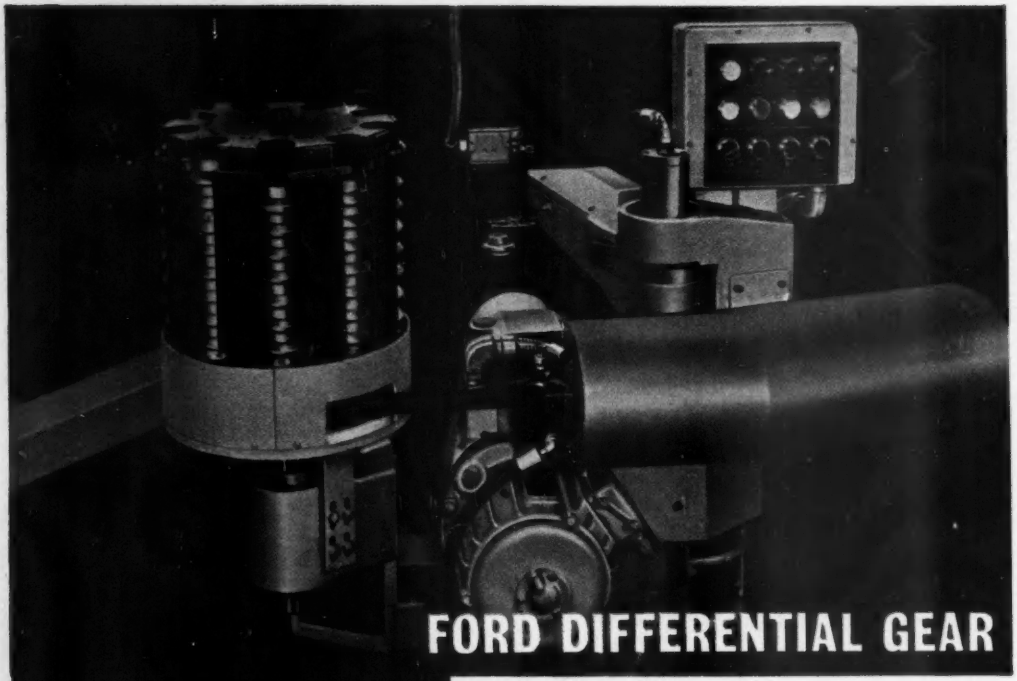
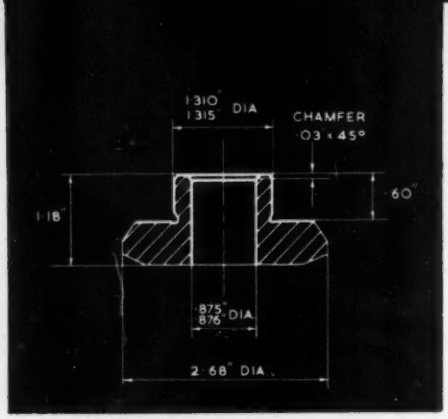


FORD DIFFERENTIAL GEAR



MACHINED IN 24 SECONDS WITH AUTOMATIC LOADING

The photograph shows the automatic loader fitted to a No. 6 Ryder Verticalauto supplied to The Ford Motor Company Limited. It is used in the production of differential gears, which are finish-bored, turned and faced at the rate of one component in 24 seconds. The magazine carries enough components for a forty minute run.

Automatic loading can be fitted to all sizes of Ryder Verticalautos.

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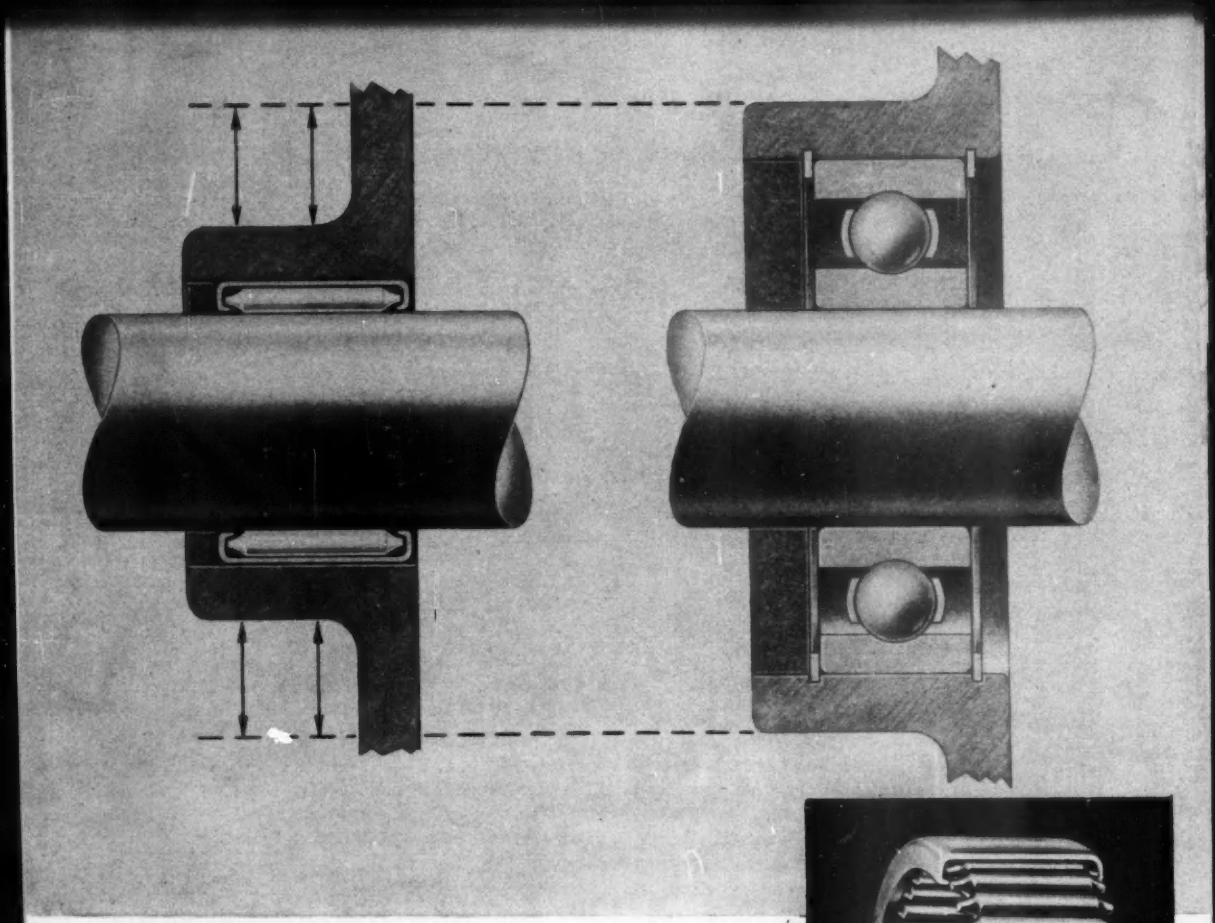

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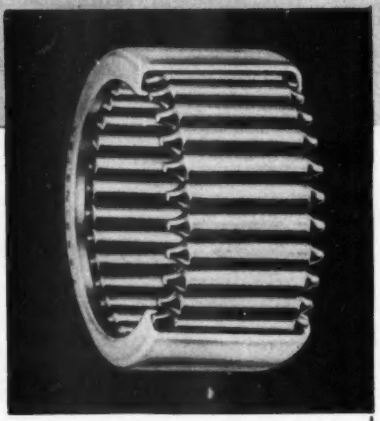

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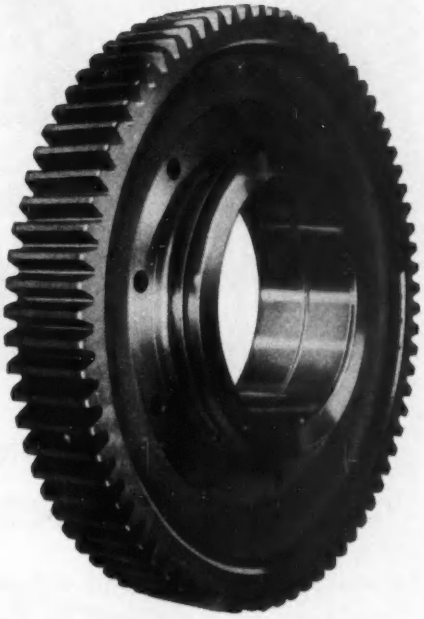

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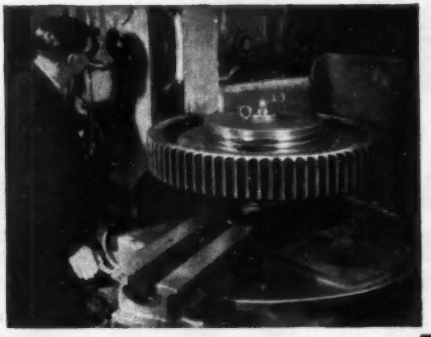
Write for our latest literature on the GC. 48" Gear Grinding Machine.



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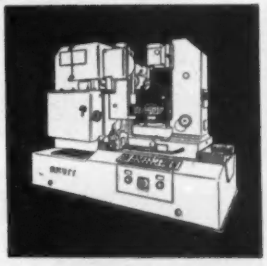

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AN INCREASE OF 10%

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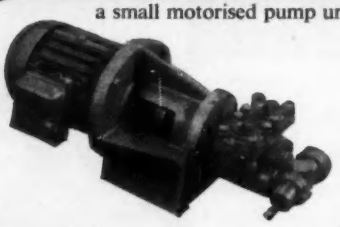
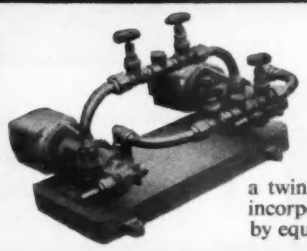
are handling a larger proportion than ever

a small motorised pump unit





a twin pumping set incorporating stand-by equipment

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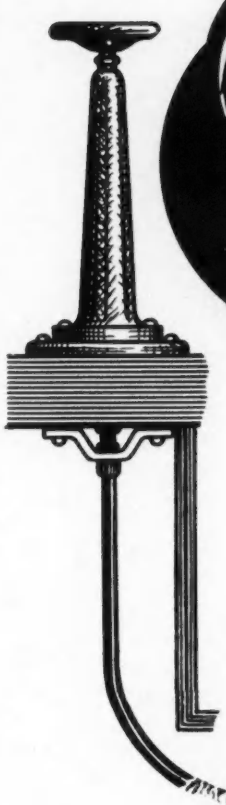

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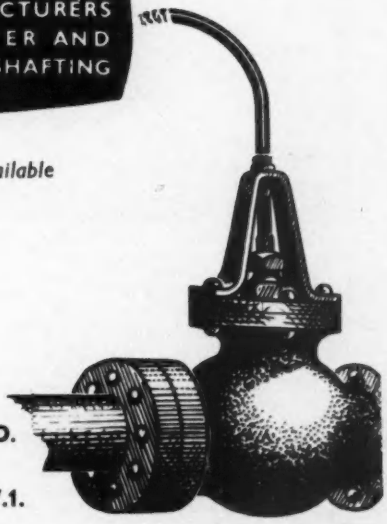

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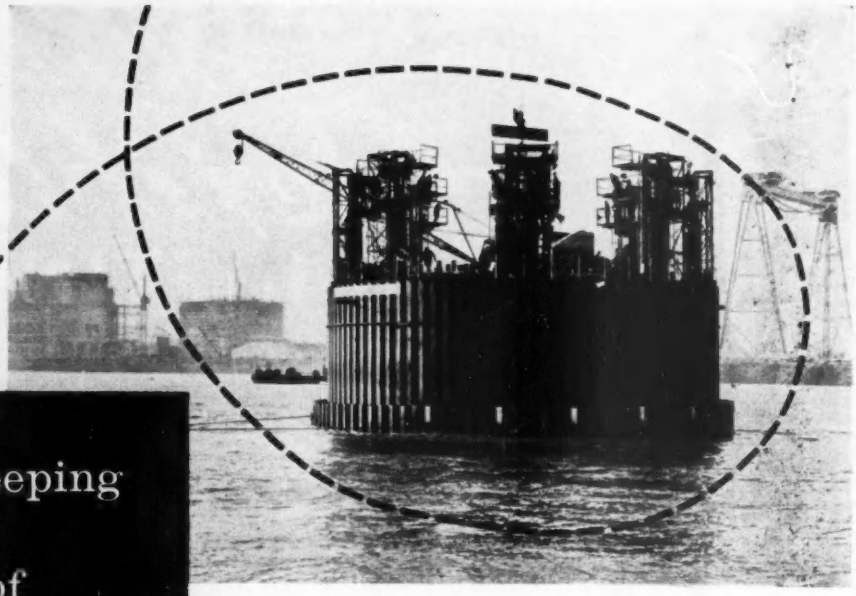

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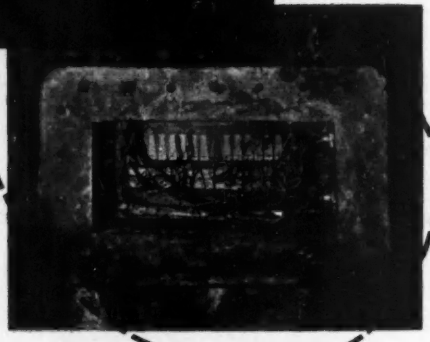

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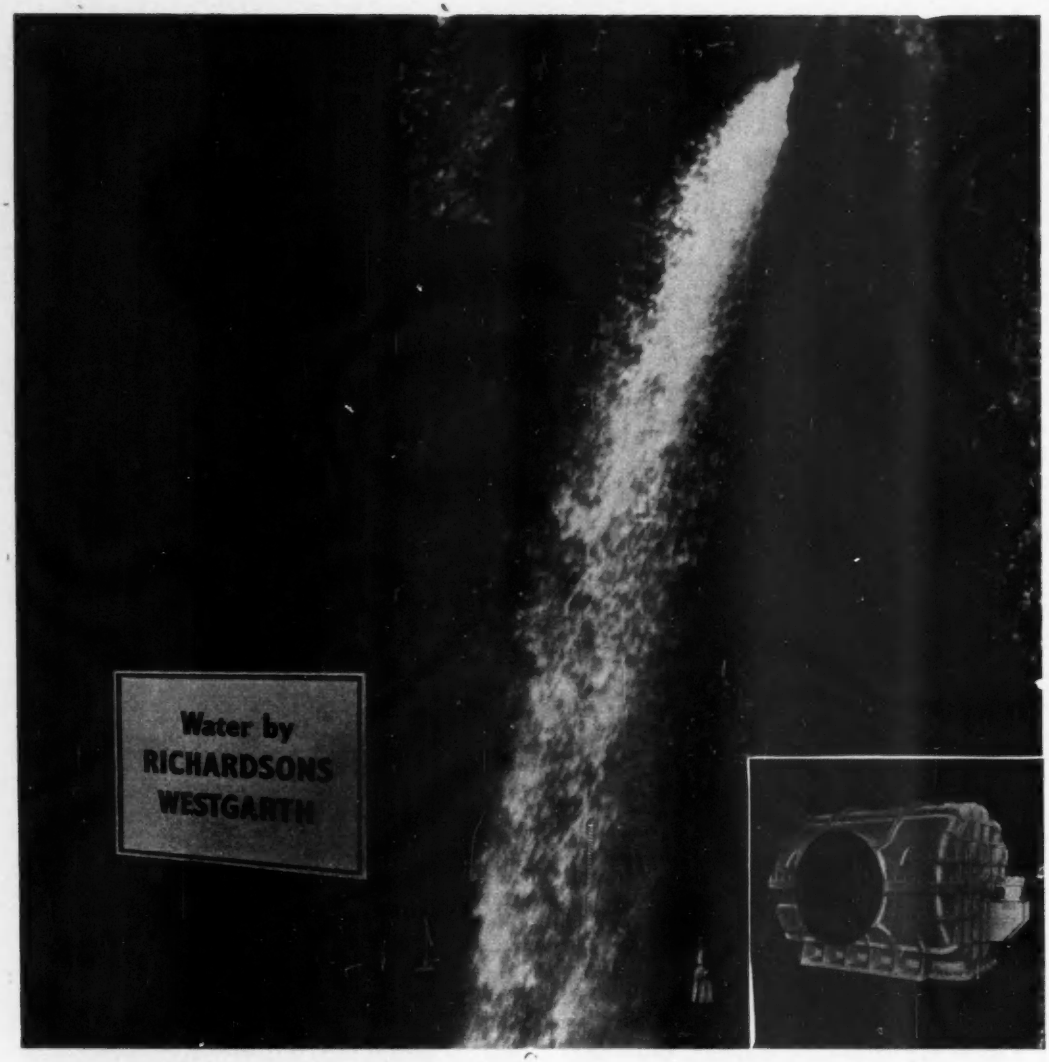

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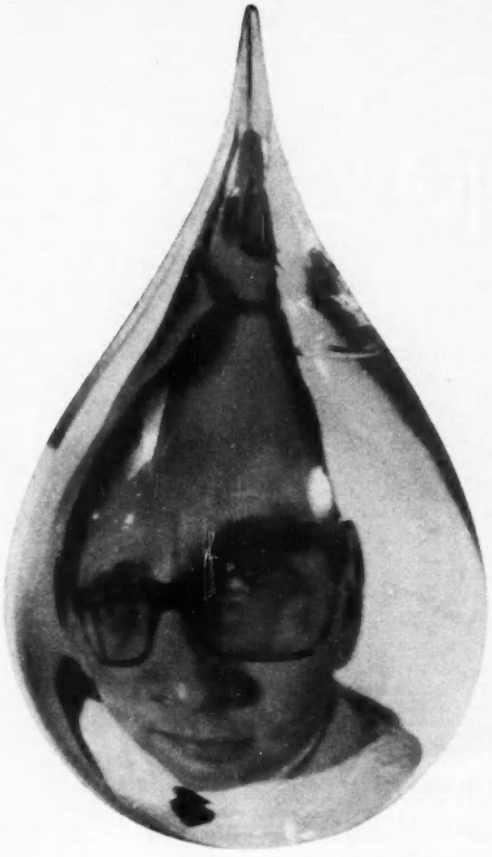

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As will be seen from the sectional drawing and the photograph, the sleeve embodies ducts for the hydraulic fluid, and is extensively machined. 'Lemax' heat-treated pearlitic malleables have versatile attributes, the ability to cast cored ducts of three-dimensional curvature, in combination with great mechanical strength, adequate shock resistance and the requisite degree of hardness.

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *ULTRA-HIGH-POWER X-RAY EQUIPMENT*

Stated to be the most powerful X-ray machine in the world specifically designed for the high-speed radiography of metals, a new 8-MeV linear accelerator under construction in the U.S.A. produces X-rays by "firing" high-energy electrons in a straight line down an evacuated tube by means of travelling radio-frequency waves which accelerate the electrons until they approach the speed of light. At the end of the tube, the electrons strike a tungsten target, producing X-rays which are beamed onto the material under examination. The operating head or tube of the equipment is 11 ft in length and 30 in. in diameter and has a 12-in. radiation aperture.

With 8 MeV, the equipment will produce 6000 roentgens per minute and, while it is true that other types of equipment sometimes employ higher voltages, they do not produce X-rays of such high intensity. Thus, for example, at full power and at a distance of 9 ft, the 5-mm focal-spot source can X-ray an 11-in. thickness of steel in about 1 minute, or a 16-in. thickness in about 18 min. The 1-mm focal-spot source incorporated as an alternative provides even greater clarity or resolution, being capable of radiographing 8 in. of steel in about 1 min, or 14 in. in about 30 min, as compared with an exposure of 1 hour and less resolution for from 3 to 4 in. of steel with currently available equipment.

From the *High-Voltage Engineering Corp.*, U.S.A., November 1960.

● *DOUBLE-DECK RESISTANCE STRAIN-GAUGE*

A new type of stress transducer has been developed to separate bending strain from the total strain at any point in shell or plate structures. Composed of two foil strain-gauges mounted on opposite faces of a plastic spacer, the new gauge does away with the necessity of mounting strain-gauges on both sides of the structure. As the two gauges are packaged in a single moisture-proof unit, mounted directly on the outside of the structure, the tedious measurements hitherto required for determining exact matching locations and orientation of back-to-back gauges are eliminated. Also, since both gauges are mounted externally, fluid compatibility and hydrostatic correction are no longer problems, while lead-wire problems are also greatly simplified.

The principle of the new transducer is simply an extension of the classic method of analysing a strain situation with gauges mounted back-to-back. Attachment of any kind of strain-measuring system to a metal surface reinforces or stiffens the surface to some degree, so that the strain at the test location will be slightly less with the extra attachment than without it. The gauge must therefore be so designed that this effect is held below a value affecting engineering accuracy. The new transducer involves the additional problem of providing enough distance between the two foil gauges to provide a significant difference in the signals from each, in order to give accurate measurements.

As designed at present, these bending-separator gauges have a maximum reinforcing effect of 2% and can yield a signal difference between the two gauges of from 50 to 100%. To achieve this, the width of bare metal to which the gauge is attached must be at least seven times the separator width, while the separation distance must be at least 50% of the metal thickness. For this reason, a series of three gauges, each with a different separation distance, has been devised to cover a common range of metal thicknesses, and can be used for mounting on any material with a modulus of elasticity greater than 6×10^6 psi.

From *Product Engineering*, U.S.A., October 10, 1960, pp. 55–57.

● *METAL-SPRAYING TECHNIQUE USING RODS IN PASTE FORM*

Conventional methods of spraying metals or other materials which are solids at room temperature are successfully used in industry, but have certain inherent disadvantages. Thus, if molten material is used, a container and heater for the molten metal, as well as a refractory nozzle, must be used. On the other hand, if the material to be sprayed is in powdered form, it is difficult to ensure proper fusion of every particle during its passage through the heating medium. It is true that these difficulties are largely overcome if the material is in the form of a rod or wire, but many materials are difficult to obtain or produce in this form and are sometimes very fragile.

It is the object of a recently patented metal-spraying technique to overcome these difficulties

Heat Treatment

Reproduction of the subtleties of steel conditioning as determined in the Laboratory relies as much upon the man as upon modern instrumentation. Experience—most often handed down from father to son—alone can ensure the correct interpretation of the effects of time and temperature established as the result of research. Firth Brown are proud of the wealth of stored experience in the heat-treatment of steel, some of it matured by three generations of service at Atlas Works.

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by mixing the powdered material to be sprayed with a suitable paste-forming binder and then extruding the mass into a pasty rod, which is then used in conjunction with specially designed spraying apparatus. A typical paste-forming material is a solution of sugar, glycerine, methyl-cellulose, or starch. Other materials which it is required to spray may not require a binder to produce a pasty rod. For example, a material of a thermoplastic type can be extruded under pressure into the form of a pasty rod, with or without preliminary heating, according to the particular characteristics of the material in question. Alternatively, a thermoplastic material can be utilized as a paste-forming material by mixing it with the material to be sprayed before extruding the mixed mass.

The pasty rod produced by extrusion in this manner is subjected to heating and to a spray-producing gaseous propellant at a point near the aperture from which it is extruded, thus avoiding the necessity for supporting the rod as it emerges from the aperture. In general, the paste-forming binder is selected in such a way that it will either burn or vaporize, and consequently will not be deposited as a solid or liquid on the surface to be sprayed.

From *Brit. Pat. Spec.* 851,594,
W. E. Ballard and U.K. Atomic Energy Authority.

● ***PHOTOMULTIPLIERION GAUGE FOR MEASURING ULTRA-HIGH VACUUM***

A new laboratory tool, designated a photomultiplier ion gauge, has recently been developed for measuring pressures of less than 10^{-12} atm, and is stated to have several advantages over conventional low-pressure measuring devices for many critical ultra-high-vacuum experiments. Thus, conventional instruments measure extremely low pressures by placing electrical charges on the gas particles remaining in a vacuum system and then counting the rate at which these charged particles or ions form. Normally, these charges are derived from electrons which are boiled off the surface of a hot tungsten filament located inside the vacuum system and in contact with the gas being measured. In many cases, however, the gas interacts with the hot filament, breaking down the gas and converting it to an entirely different substance, with consequent contamination and failure of the entire experiment.

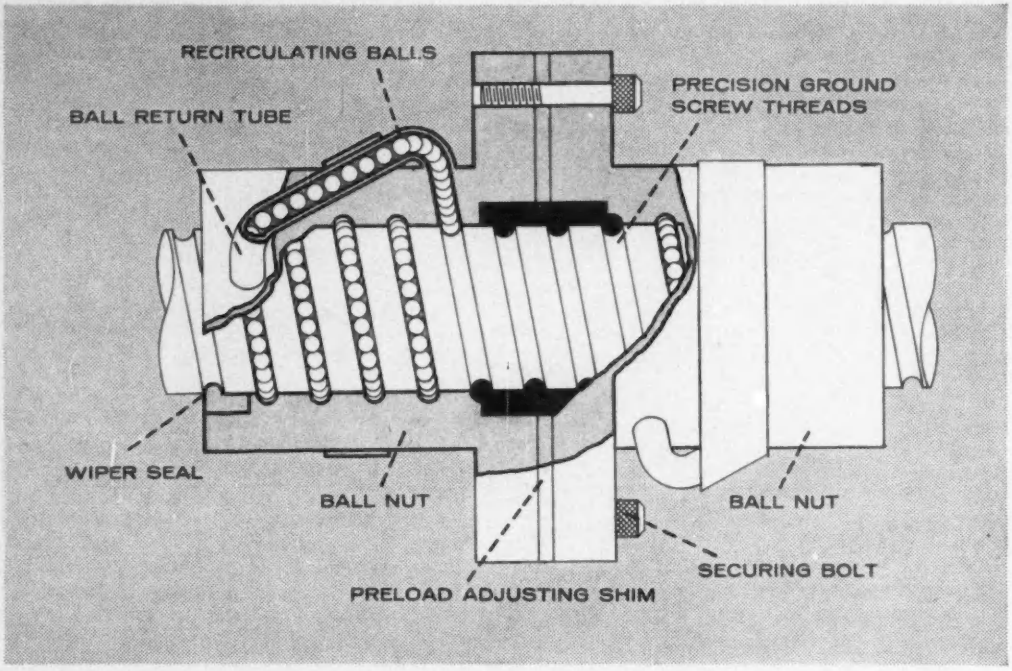
The new gauge overcomes these difficulties by eliminating completely the heated tungsten filament, a beam of ultraviolet light being used instead of a hot surface. The light is beamed onto a metal surface with the ability to release electrons under the stimulus of the ultraviolet rays, and these electrons are then guided onto a series of similar surfaces which multiply the electrons in speed and number, after which they are collected and counted in the usual way. The gauge is linear with pressure over the range from about 10^{-3} to 10^{-10} mm Hg, corresponding to the range of pressures encountered in space at altitudes above the earth of between 50 and 650 miles. In fact, it has already been used in pressure measurements and other experiments aimed at providing an understanding of the concentrations and interactions of the particles found in outer space by duplication of outer-space conditions in the laboratory. Other applications of the photomultiplier ion gauge include its use in low-pressure studies of hot-filament/gas reactions, such as those encountered in fluorescent lamps, electronic valves, and thermionic-energy converters.

From *Westinghouse Electric Corporation*, U.S.A.,
November, 1960.

● ***METHOD OF PRODUCING WEAR-RESISTANT SURFACE LAYERS ON METALS***

A recently patented process is claimed to produce wear-resistant surface layers on metals, particularly on iron and iron alloys, considerably more quickly than has hitherto been possible and, at the same time, these surface layers impart to the treated metal a markedly lower coefficient of friction than its original value. For this reason, it is stated that the process is particularly suitable for application to all parts of equipment subject to friction, typical examples being camshafts, gearwheels, bearing boxes, bushes, bearing surfaces of shafts, piston-rings, cylinder walls, and drills and other cutting tools.

The process comprises treating the metal with a fused-salt bath containing from 0·1 to 5% of selenium and/or tellurium, either in metallic form or as alkali-metal compounds or salts. The efficacy of the salt bath depends on its temperature, optimum results being obtained at temperatures between about 450 and 700°C. As a typical example, cast iron can be treated by dipping for 1 hr in a fused-salt bath containing 30% potassium cyanate, 30% sodium cyanide, and 1% sodium selenite, with 5% potassium chloride, and 34% sodium carbonate, sodium oxide, and sodium hydroxide, the treatment temperature being 560°C. Similarly, mild steel can be treated at 700°C for 1 hr in a bath containing 0·5% sodium tellurate, 20% sodium cyanide, 15% calcium cyanate, 10% barium chloride, and 54·5% sodium chloride, while a suitable bath for an alloy steel containing 0·4% carbon and 1% chromium comprises 50% potassium cyanate, 30% sodium cyanide, and 1% sodium selenite, with 5% sodium hydroxide, 9% sodium chloride, and 5% sodium carbonate, the treatment in this case being carried out at 520°C for 1 hr. It should be appreciated that the surface produced by this process comprises two layers. Of these, the thin upper layer can be



Beaver pre-loaded ball screws, up to 95% efficient, operate at −52° C to over 400° C with no backlash

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of—52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

**Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

For further information please write to:
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rubbed off fairly easily and greatly reduces friction in the same way as a lubricant, while the lower layer adheres firmly to the base metal and is wear-resistant. The treated metals show only a very slight increase, if any, in surface hardness, so that the process is not analagous with a carburizing or nitriding treatment.

From *Brit. Pat. Spec.* 854,208.
Deutsche Gold- und Silber-Scheideanstalt, Frankfurt.

● *HIGH-TEMPERATURE HAFNIUM TITANATE STRUCTURAL CERAMICS*

A new group of hafnium titanate ceramics, now under development, combines low thermal expansion with an unusually high melting point, making them appear to be highly promising for high-temperature structural applications. Although their melting point is about 4000°F, their maximum service temperature at present is limited by an apparent phase change which occurs in the material at about 3400°F, and current research aims at modifying compositions so as to prevent this phase change, enabling hot-face temperatures to be extended to the melting point. The thermal-expansion characteristics of these new materials are not unique. However, compared with other low-expansion ceramics, hafnium titanates have exceptionally high permissible service temperatures.

Compositions containing from 14 to 19% titania produce very low and negative expansions. For the purpose of determining whether it is necessary to use expensive high-purity hafnia for the preparation of the compositions, varying proportions of zirconia have been added to the hafnium titanate bodies, and have been found to decrease thermal expansion. Density also decreases with increasing zirconia content, as would be expected, because of the lower density of zirconia. Little change in porosity occurs, the addition of 2% zirconia producing the lowest porosity. Thermal shock resistance has been determined by placing specimens in alundum boats, sliding them into a zone at 2500°F and, after 10 min, drawing the specimens out of the furnace and cooling them either in air or by water-quenching, the latter being found to be definitely detrimental to the material.

From *Materials in Design Engineering*, U.S.A., October 1960, pp. 16–18.

● *SONIC THICKNESS-MEASURING INSTRUMENT*

A recently patented portable thickness-measuring instrument utilizes a sonic measuring system to detect the thickness of material by notin the frequency of a signal which excites standing waves within the material. The frequency of an oscillator is swept across a predetermined portion of the frequency spectrum, and the electrical energy from the oscillator and the sonic energy within the material whose thickness is to be determined are interchanged by means of an electro-acoustic transducer.

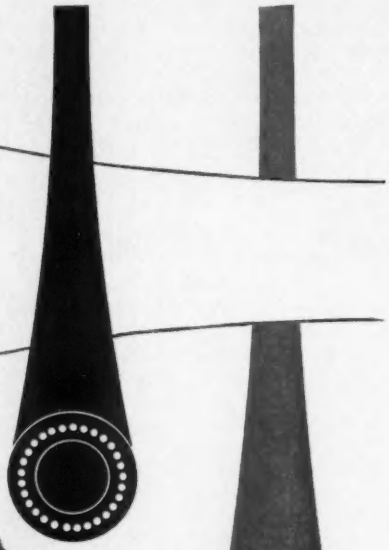
The frequencies at which the oscillator is heavily loaded are visually indicated along a first scale, the indication obtained then being a direct measure of the half-wavelength of each mode excited within the material. To determine the thickness of the material, a second scale is provided, which has markings related to the integral harmonics and is alignable along the first scale. By aligning markings along adjacent visual indications on the first scale, an index on the second scale points directly to the thickness of the material being tested. The oscillator frequency is swept by rotating the rotor plates of a variable capacitor and, synchronously with the rotation of the rotor plates, a neon lamp is rotated behind the first indicating scale and is visible through it. The position of the bulb is then indicative of the oscillator frequency. Means are provided for illuminating the bulb, when a resonant mode is excited in the material under test, thus effecting a visual flash on the first scale, which is calibrated in mode half-wavelengths. When several modes are excited during a single sweep, flashes will appear at a number of points on the first scale. The second scale is then turned until adjacent markings are aligned with the flashes on the first scale, and the index on the second scale then points on the first scale to the actual thickness of the material.

From *Brit. Pat. Spec.* 842,241.
Magnaflux Corporation, Chicago, Ill., U.S.A.

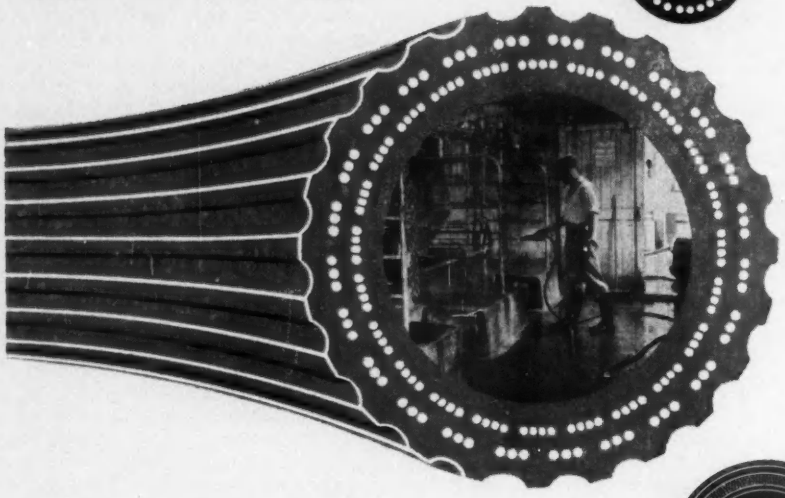
● *PREVENTION OF SHRINKAGE OF PLASTIC FIBRES AND FILMS*

The irradiation of threads, fibres, bands, and films of synthetic linear polymerization products, such as polyvinyl chloride and polythene, and of polycondensation products, such as the polyamides, is known to improve their heat resistance and also makes them more resistant to the action of substances having a solubilizing and swelling action. At the same time, however, these polymers are subjected to considerable attack, to which compensation must be made, especially where high strength is required. In addition, irradiation gives rise to a decrease in the tendency of the material to shrink at high temperatures. It is now reported, however, that a recently patented process makes it possible to decrease the shrinking tension still further, thereby limiting the loss in absolute strength.

Essentially, the process involves treatment of the material with a swelling agent in such a way that the slightly swollen part contains not more than 25% by weight of the swelling agent, and then irradiating it with ionizing rays. This



YOU NAME THE JOB WE HAVE THE HOSE



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combined treatment leads to a decrease in shrinking tension, exceeding that which can be obtained by swelling or irradiation alone. The loss in absolute strength is reduced because the irradiation dose required is less than that generally necessary in conventional irradiation methods.

The treatment can be applied to a wide range of products, including thin-walled hollow objects, such as bottles and capsules. Thicker items, such as gearwheels and bearings, give rise to greater difficulties, but a superficial swelling and a not very penetrating irradiation suffice. Threads and fibres need not be treated as such, but may be submitted to combined swelling and irradiation treatment in the form of woven fabrics or cords, expecially tyre cords.

Swelling can be produced by such agents as water and various alcohols (e.g., methanol, ethanol, and cyclohexanol) and so-called "carriers", such as diphenyl, 2-hydroxydiphenyl, chlorobenzenes, and methyl salicylate, which increase dye absorption in the dyeing of hydrophobic polymers. In addition to chemically inert swelling agents, agents which react under the influence of the ionizing rays with polycondensation products and form cross-links can be used, an example in the case of polyamides being 1-hydroxy-2 : 5-dichloro-methylbenzene, and, in the case of polythene, acrylonitrile.

From *Brit. Pat. Spec. No.* 852,954.
N.V. Onderzoekingsinstituut Research, Netherlands.

● *FOAM-VAPORIZATION CASTING*

Foam vaporization casting can provide a solution to one of the most difficult problems in electronic engineering, i.e., the production of engineering models of cast components in the shortest possible time, and is also of advantage in short-run production, very nearly approaching the ideal solution of manufacturing a part without tooling. In foam-vaporization casting, the pattern is made from polystyrene foam, which is easily worked and can be glued to make complicated shapes, the principal difference between this method and other forms of casting being that the pattern is not removed from the mould. When the polystyrene pattern has been rammed into the sand and the gates and risers are cut, the metal is poured directly onto the pattern. The foam vaporizes when it is contacted by the molten metal, and the metal fills the mould cavity created by vaporization.

It might be expected that excessive gas would be generated by this process, but this is not the case, as the metal is not subjected to greater gas development than in any other method of moulding, and no unusual gas evolution is observed when the metal is poured into the mould. Castings of practically unlimited complexity can be made by this method, which appears to be suitable for any type of metal that can be poured by conventional foundry techniques. The castings show a rough surface, owing to the surface condition of the polystyrene foam, but a better surface condition can be obtained by smoothing the surface of the pattern. In production quantities, the polystyrene patterns can be made with a fixed gating system attached.

From *Electronics*, U.S.A.,
November 4, 1960, pp. 86, 88–89.

● *TANTALUM AS AN ALLOY BASE*

The need for structural materials for use at temperatures above 2000°F has led to the consideration of tantalum as an alloy base. because, despite its high density, tantalum possesses the advantages of a very low ductile-to-brittle transition temperature, a refractory oxide, and a high melting point. As part of a broad investigation into the strength and oxidation properties of tantalum the effects of alloying on the oxidation behaviour of tantalum have been examined, leading to the following conclusions:—

The most effective binary additions for improving tantalum oxidation at between 1000 and 1400°C are the Group IVA elements titanium, zirconium, and hafnium. Moderate improvements result from adding vanadium, columbium, chromium, molybdenum, tungsten, silicon, boron, iron, and nickel. The depth of subsurface contamination hardening of tantalum is significantly reduced by thorium, silicon, vanadium, titanium, and tungsten, which, with the exception of vanadium and tungsten, form oxides that are more stable than tantalum oxide, resulting in the formation of an internal oxide dispersion. The oxidation behaviour of the tantalum ternary alloys investigated was found to be about an average of that obtained when the same elements were added as binaries. The oxidation behaviour of tantalum alloys can be correlated with the ionic radius of the addition and with the properties of the oxide of the addition element, while the effects of alloy additions on the contamination behaviour of tantalum can be correlated with the thermodynamic oxide stability, atom diameter, and melting point of the alloy additions.

From *Battelle Technical Review*, U.S.A.,
October 1960, pp. 15–16.

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Analytical Cutting-Tool Design

THE efficiency of cutting tools can be greatly affected by changes in tool profile or shape. In fact, it is generally conceded by the metal-cutting industry that there exists an optimum cutting-tool geometry for every different workpiece material, though little effort has been devoted towards the determination of these optimum geometries because of the lack of a technological and economical approach to the problem. Indeed, the industry relies on two or three standard tool designs per operation to resolve its tooling problems.

Most metal-cutting investigators agree that cutting-tool design needs to be developed more precisely in order to improve machining efficiency. This problem is being studied in the U.S.A. by Chance Vought Aircraft Incorporated, and the initial results are presented in this report, which reviews the essentials of cutting-tool geometry, presents them in a simplified manner, and extends the principles developed to practical applications.

Tool Signature

Probably the most common cutting tool is the ordinary lathe tool, which is simply a single-point tool with two cutting edges, i.e., a side cutting edge and an end cutting edge. The geometry for other types of cutters, such as milling cutters and drills, can be related to that of a lathe tool, but the lathe tool, because of its simplicity, is used as an example throughout most of this report. The relationship between a milling cutter and a lathe tool will be given later.

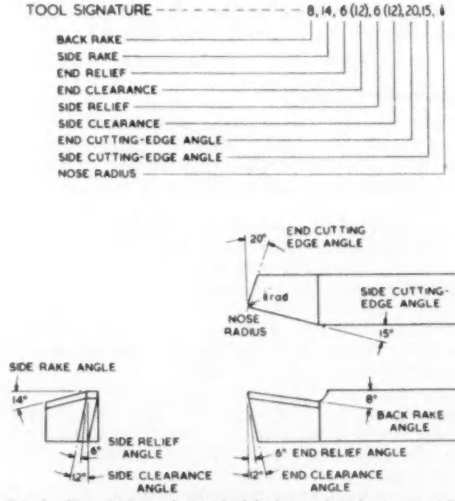


Fig. 1. Description of a typical lathe tool and corresponding tool signature.

Tool signature or tool designation is a short-hand method of describing tool geometry, as illustrated in Fig. 1, which shows the description of a typical lathe tool and the corresponding tool signature. All the angles included in the tool signature can be measured with a good degree of accuracy by means of a "shadowgraph" or other optical equipment.

Orthogonal Cutting

Orthogonal cutting can be more simply described as two-dimensional cutting, and derives its name from the fact that the mechanism of cutting can be described by the use of only one plane. Thus, referring to the orthographic view of orthogonal cutting in Fig. 2c, it will be appreciated that a plane has only two dimensions, i.e., length and breadth, as indicated in the side view in

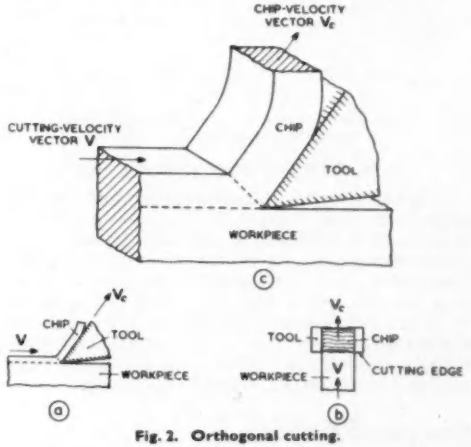


Fig. 2. Orthogonal cutting.

Fig. 2b. In addition, such a cutting operation has another dimension, i.e., width, as shown in the top view in Fig. 26, where the cutting edge of the tool is perpendicular to the cutting-velocity vector **V**. The plane of any cross-section taken through the cutting zone perpendicular to the finished surface and parallel to the cutting-velocity vector **V** is identical with the plane of Fig. 2a, which therefore describes the mechanics of the cutting operation throughout the width of the cut.

The cutting-velocity vector **V** represents the velocity at any point on the workpiece and the direction in which this point moves through space as it approaches the cutting tool. As a simplification, the cutting-velocity vector **V** is assumed to act tangentially to the workpiece at the cutting tool in a lathe turning operation.

The chip-velocity vector $\mathbf{V}_c$ represents the velocity of

the chip as it leaves the shear plane and the direction it takes in space, relative to the cutting-velocity vector **V**, as it is deflected by the cutting tool. For orthogonal cutting, the chip-velocity vector $\mathbf{V}_c$ is essentially parallel to the tool face and perpendicular to the cutting edge.

Owing to their simplicity, orthogonal cutting tools are used extensively in metal-cutting research; however, some practical applications are to be found for surface broaching, for finishing planer cuts, for lathe cut-off operations, and for some plain milling operations.

Three-Dimensional Cutting

A three-dimensional or oblique cutter can most easily be described as a straight cutting edge which is inclined from a normal to the cutting-velocity vector **V**, as shown in Fig. 3. The inclination angle i is the distinguishing feature of all three-dimensional cutting operations and represents the point of departure from the orthogonal case. The inclination significantly alters the chip flow and hence the performance of a tool.

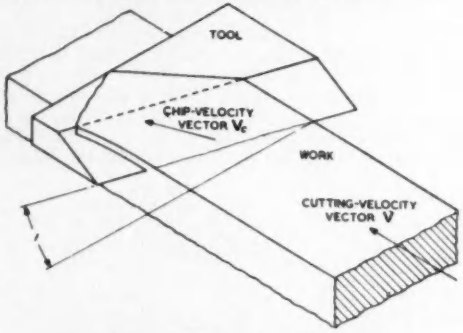


Fig. 3. Three-dimensional or oblique cutting.

The most practical three-dimensional tools have two edges which cut simultaneously. Using a lathe tool as an example, the primary cutting edge is the side cutting edge, while the secondary cutting edge is the end cutting edge. Since the depth of cut is usually much greater than the feed per revolution, the effect produced along the secondary cutting edge is negligible in comparison with that along the primary cutting edge. Typical examples of three-dimensional or oblique cutting include lathe turning, face milling, slab milling, and drilling.

Computed Angles

The nomenclature for those cutting-tool angles which are not easily visualized or readily measurable will now be discussed, and equations will be given for these angles in terms of the easily measured tool-signature angles. The four computed angles, in order of importance, are the effective rake angle α_e, the inclination angle i, the normal rake angle α_n, and the velocity rake angle α_v, though it should be appreciated that, in order to derive these angles, it is necessary to depart from this order of relative importance.

Inclination Angle

For simplicity, a lathe tool without clearance or end cutting-edge angles is shown in Fig. 4a to indicate the inclination angle *ACB*. The inclination angle i, which is defined as the angle formed by the tool cutting edge and

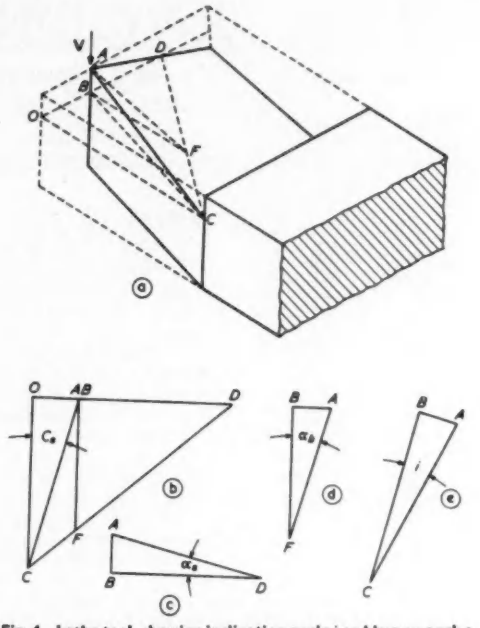


Fig. 4. Lathe tool, showing inclination angle i and known angles C_s, α_s, and α_b.

a normal to the cutting-velocity vector **V**, is also shown in Fig. 4e, which is a view looking perpendicular to the plane *ABC* in Fig. 4a, in which the plane *OBDC* is drawn perpendicular to the cutting-velocity vector **V**.

The known angles, i.e., the side cutting-edge angle C_s, the side rake angle α_s, and the back rake angle α_b are shown respectively in Fig. 4b, which is a plan view looking in the direction of the cutting-velocity vector **V**. in Fig. 4c, which is a view looking perpendicular to the plane *ABD*, and in Fig. 4d, which is a view looking perpendicular to the plane *ABF*. Because triangles *ODC* and *BDF* are similar, the inclination angle i can be expressed in terms of these known angles as

$$\tan i = \tan \alpha_b \cos C_s - \tan \alpha_s \sin C_s \quad \ldots \quad (1)$$

Velocity Rake Angle

The velocity rake angle α_v, sometimes referred to incorrectly as the true rake angle, is the angle formed by the tool face and a normal to the finished surface in a plane containing the cutting-velocity vector **V** (plane *OB* in Fig. 5).

The derivation of the velocity rake angle α_v is found in much the same manner as for the inclination angle i. For simplicity, a lathe tool, again without clearance or end cutting-edge angle, is illustrated in Fig. 6a to show the velocity rake angle *AEB*. The velocity rake angle α_v is also shown in Fig. 6e, which is a view looking perpendicular to plane *ABE* in Fig. 6a. The side cutting-edge angle C_s is shown in Fig. 6b, which is a plan view looking in the direction of the cutting-velocity vector **V**, the back rake angle α_b in Fig. 6c, which is a view looking perpendicular to the plane *ABF*, and the side rake angle α_s in Fig. 6d, which is a view looking perpendicular to the plane *ABD*.

From these known angles, the velocity rake angle α_v can, using the similar triangles *GDE* and *BDF*, be

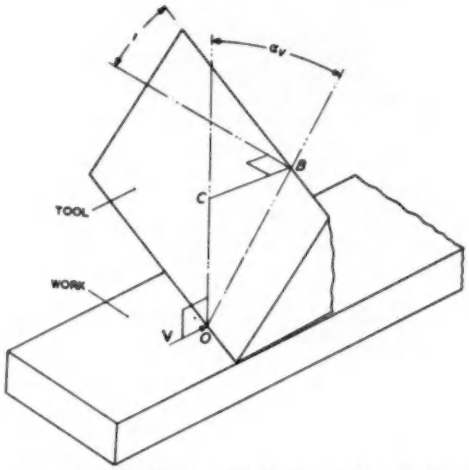
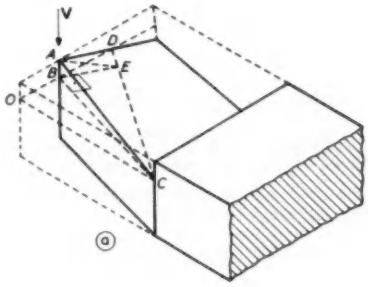


Fig. 5. Velocity rake angle α_v and inclination angle i on an oblique cutting tool.



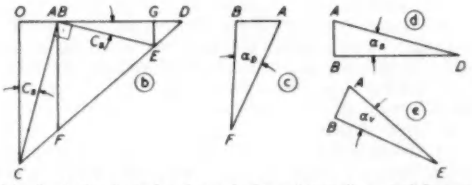


Fig. 6. Lathe tool showing velocity rake angle α_v and known angles C_s, α_s, and α_b.

derived as

$$\tan \alpha_v = \tan \alpha_s \cos C_s + \tan \alpha_b \sin C_s \quad .. \quad (2)$$

Normal Rake Angle

The normal rake angle α_n, sometimes called the oblique rake angle, is the angle formed by the tool face and a normal to the finished surface in a plane perpendicular to the tool cutting edge (plane OA in Fig. 7). The relative positions of the velocity rake angle α_v and the normal rake angle α_n on a lathe tool are shown in Fig. 8.

The normal rake angle α_n can be calculated by using a relationship between the velocity rake angle α_v and inclination angle i, as shown in Fig. 9a, and also in Fig. 9b, which is a plan view looking perpendicular to the side of the workpiece, in Fig. 9c, which is a plan view looking parallel to the tool face from the side, and in Fig. 9d, which is a plan view looking perpendicular to the top of the tool. From these relationships, the normal rake

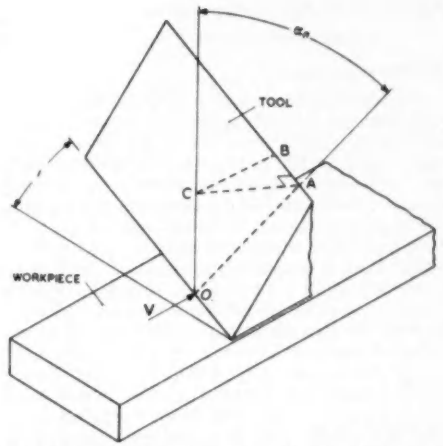


Fig. 7. Normal rake angle α_n and inclination angle i on an oblique cutting tool.

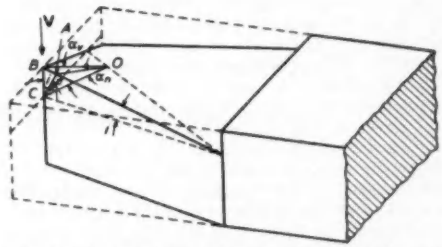
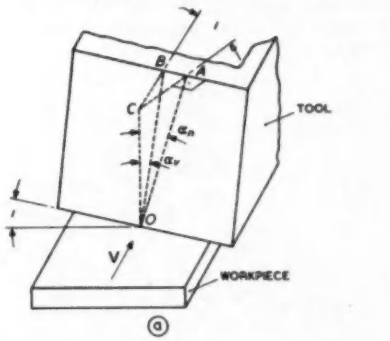


Fig. 8. Relative positions of the velocity rake angle α_v and normal rake angle α_n on a lathe tool.



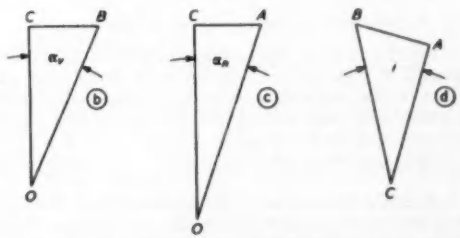


Fig. 9. Oblique tool, showing velocity rake angle α_v, normal rake angle α_n, and inclination angle i.

angle α_n can be expressed as

$$\tan \alpha_n = \tan \alpha_v \cos i \quad .. \quad .. \quad .. \quad (3)$$

Effective Rake Angle

The effective rake angle α_e is the complement to the angle between the cutting-velocity vector **V** and the chip-velocity vector $\mathbf{V}_c$. The angle (90—α_e) is the angle through which the metal is deflected by the cutting tool, as shown in Fig. 10. It should be noted that the plane in which α_e lies is not perpendicular to the finished surface of the workpiece, but is inclined from the normal.

In order to determine the effective rake angle α_e for oblique tools, it is necessary to know the direction taken by the chip across the tool face. This direction is most effectively specified by the chip-flow angle η_c, which is the angle between the chip-flow direction and a normal to the cutting edge, measured in the plane of the tool face, as indicated by angle *EAH* in Fig. 11a, which shows the chip-flow angle η_c for a lathe tool. Determination of the chip-flow angle η_c can be simplified by applying Stabler's Law, which states that, to a first approximation, η_c is equal to the inclination angle *i*. Actually, however, η_c has been found in some cases to be as much as 20 deg. larger than angle *i*, but this approximation will have to be used until a better approximation is found or unless the value of η_c is determined by physical measurements.

In Fig. 11, the effective rake angle α_e is shown in Fig. 11a and also in Fig. 11g, which is a view looking perpendicular to the plane *ABH*. The velocity rake angle α_v is shown in Fig. 11a and also in Fig. 11f, which is a view looking perpendicular to the plane *ABE*. The inclination angle *i* is shown in Fig. 11b, which is a plan view looking in the direction of the cutting-velocity vector **V**, and also in Fig. 11d, which is a view looking perpendicular to the plane *ABC*. The side cutting-edge angle C_s is also shown in Fig. 11b. Fig. 11c, which is a view looking perpendicular to the plane *ABF*, shows the back rake angle α_b, and Fig. 11e, which is a view perpendicular to the plane *ABD*, shows the side rake angle α_s.

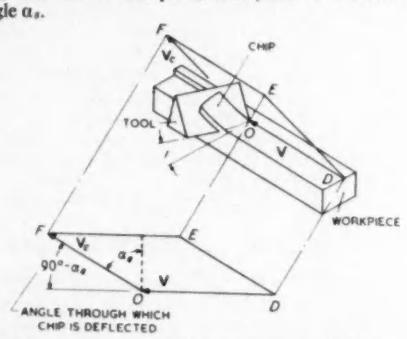


Fig. 10. Effective rake angle α_e for an oblique cutter.

Bearing in mind that triangles *BFD* and *KHD* are similar, it is possible to derive an expression for the effective rake angle α_e in terms of the back rake angle α_b, side rake angle α_s, side cutting-edge angle C_s, and inclination angle *i*, *viz*:-

$$\tan \alpha_e = \tan \alpha_s \cos (C_s + i) + \tan \alpha_b \sin (C_s + i) \quad (4)$$

It should be noted that, in the derivation of eq. (4), it has been assumed that the inclination angle *i* (angle *EAH* in Fig. 11b) is equal to angle *EBH*. In actual fact, this is not strictly true, as *A* and *B* lie on different planes,

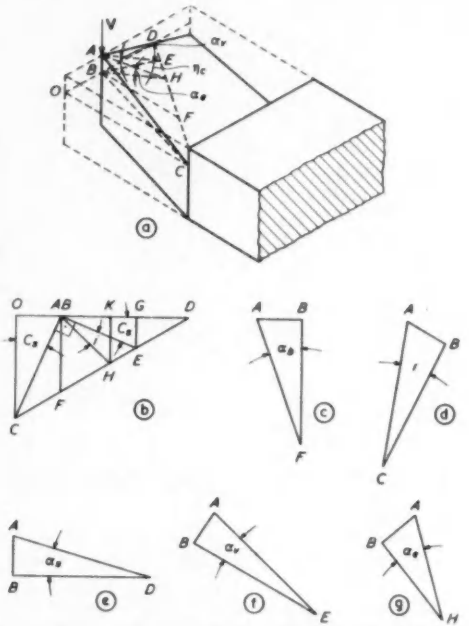


Fig. 11. Lathe tool, showing effective rake angle α_e, chip-flow angle η_c, velocity rake angle α_v, side cutting-edge angle C_s, inclination angle *i*, back rake angle α_b, and side rake angle α_s.

but the error introduced by this assumption is negligible over a practical range.

Comparison of Orthogonal and Three-Dimensional Cutting

A comparison of orthogonal cutting with three-dimensional or oblique cutting shows that the chip-flow direction for orthogonal cutting, when measured in the plane of the tool face, is essentially perpendicular to the tool cutting edge, whereas the chip-flow direction in three-dimensional cutting is inclined to the tool cutting edge by an angle η_c.

It should also be appreciated that, since an orthogonal cutter has no inclination angle *i* or back rake angle α_b, the velocity rake angle α_v, the normal rake angle α_n, and the effective rake angle α_e all lie in the same plane.

Nomographs

Two nomographs are shown in Figs. 12 and 13, which, if properly used, enable the inclination angle *i*, the velocity rake angle α_v, the effective rake angle α_e, and the normal rake angle α_n to be read directly without any calculations. The nomograph in Fig. 12 is an extended version of Kronenberg's nomograph, and has been modified so that the effective rake angle α_e, as well as the inclination angle *i* and the velocity rake angle α_v, can be read. The nomograph in Fig. 13 (from Stabler) can be used to find the normal rake angle α_n by using the inclination angle *i* and the effective rake angle α_e found from Fig. 12.

The inclination angle *i* can be found by connecting a straight line between the back rake angle α_b and the side rake angle α_s in Fig. 12 and then reading off its value

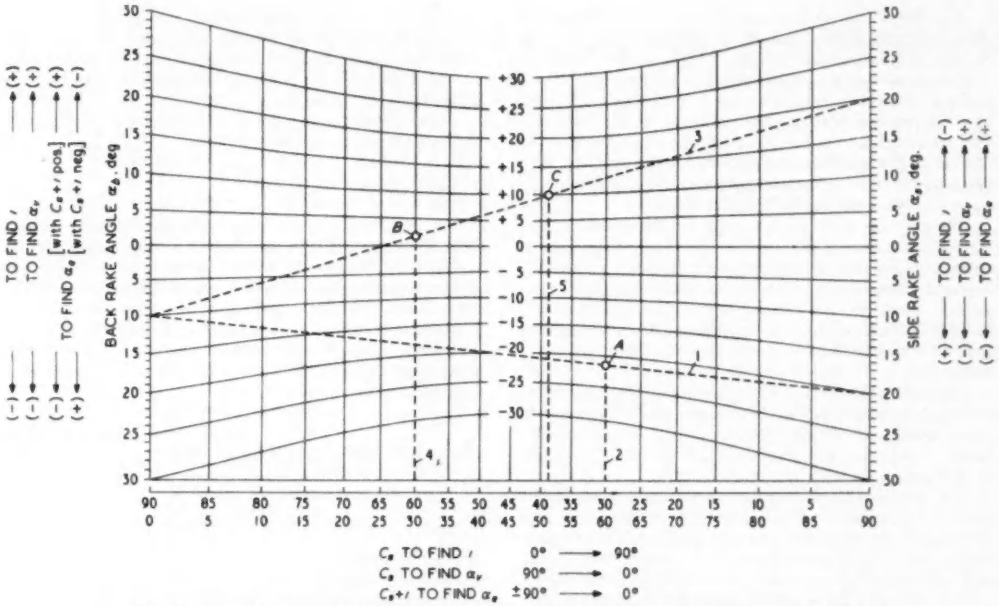

BACK RAKE ANGLE α_b, deg
SIDE RAKE ANGLE α_s, deg.
TO FIND i
TO FIND α_v
TO FIND α_e [with C_s+i pos.]
[with C_s+i neg.]
C_s TO FIND i 0° → 90°
C_s TO FIND α_v 90° → 0°
C_s+i TO FIND α_e ±90° → 0°

Fig. 12. Nomogram for locating the inclination angle i, velocity rake angle α_v, and effective rake angle α_e.

from a point above the side cutting-edge angle C_s. The velocity rake angle α_v can be found by the same method. To determine the effective rake angle α_e, the abscissa becomes the side cutting-edge angle plus the inclination angle, i.e., $(C_s + i)$. Other than this change, the effective rake angle α_e is found in the same way as the velocity rake angle α_v.

As an example, if the back rake angle $\alpha_b = -10°$, the side rake angle $\alpha_s = +20°$, and the side cutting-edge angle $C_s = +60°$, proceed as follows:—

(1) To find the inclination angle i (Fig. 12).
   (a) Draw line (1) connecting $-10°$ on the scale of the back rake angle α_b to $+20°$ on the scale of the side rake angle α_s.
   (*b*) From $+60°$ on the scale of the side cutting-edge angle C_s, draw line (2) upwards to intersect line (1) at point *A*.
   (*c*) Read off the value of the inclination angle $i = -22°$ from the curved lines on the nomograph.

(2) To find the velocity rake angle α_v (Fig. 12).
   (a) Note the change in sign convention on the α_s and C_s scales, and draw line (3) connecting $-10°$ on the α_b scale to $+20°$ on the α_s scale.
   (b) From $+60°$ on the C_s scale, draw line (4) upwards to intersect line (3) at point *B*.
   (*c*) Read $\alpha_v = +3°$ from the curved lines on the nomograph.

(3) To find the effective rake angle α_e (Fig. 12).
   (a) Draw line (3) connecting $-10°$ on the α_b scale to $+20°$ on the α_s scale.
   (b) As the abscissa now becomes $C_s + i = 60 + (-22) = +38°$, draw line (5) upwards at $+38°$ on the $(C_s + i)$ scale to intersect line (3) at point *C*.
   (c) Read $\alpha_e = +10°$ from the curved lines on the nomograph.

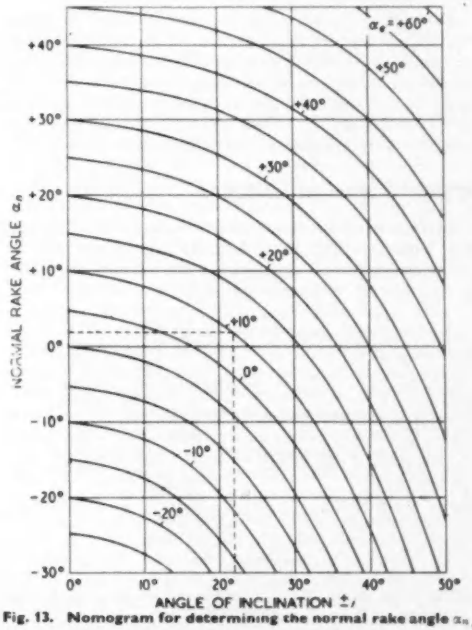


Fig. 13. Nomogram for determining the normal rake angle α_n.

(4) To find the normal rake angle α_n (Fig. 13).
   (a) From 22° on the scale of the inclination angle i, draw a line upwards.
   (b) At the point where this line intersects 10° on the α_e scale, draw a horizontal line to the scale of the normal rake angle α_n, and read off its value, i.e., $\alpha_n = +2°$.

The role of the side cutting-edge angle C_s in influencing the inclination angle i and the velocity rake angle α_v can be seen from these nomographs. If C_s is zero, the back rake angle α_b becomes the inclination angle i, i.e., $\alpha_b = i$, and the side rake angle α_s equals the velocity rake angle α_v. As the side cutting-edge angle C_s is increased, the side rake angle α_s plays an increasing part in determining the value of the inclination angle i, just as the back rake angle α_b plays an increasing part with the side rake angle α_s in determining the effective rake angle α_e.

As the side cutting-edge angle C_s increases, so too does the tendency of the tool to chatter. An increase in either the side cutting-edge angle or the nose radius will, however, cause an improvement in tool life, as well as in surface finish, up to the point where chatter is initiated. It is unfortunate that, whenever the length of the cutting edge is increased, the tendency to chatter is also increased.

Insofar as the effect of inclination angle i is concerned, it should be noted that a positive value of this angle will cause the chip to be directed away from the workpiece, while a negative value will direct the chip into the workpiece.

The recommended values of rake angles are such that the normal rake angle α_n generally decreases as the strength of the metal being cut increases. This decrease in the value of α_n provides a greater wedge angle at the tool point to support a greater load. Under severe shock conditions, or when machining very hard materials, it is frequently desirable to use negative rake angles with carbide-tipped tools.

Sometimes, when milling materials with a hardness of R_c 40 and below, it is desirable to use high-speed-steel cutters, because of the greater ability of high-speed steel to absorb shock. It is advantageous to provide high-speed-steel tools with greater rake angles, in order to take advantage of the decreased cutting energy accompanying a higher effective rake angle α_e.

Other Types of Cutters

A face-milling cutter is very similar in many respects to a lathe tool (Fig. 14), except that the nomenclature is

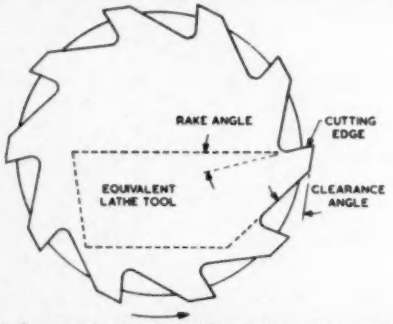


Fig. 14. Comparison of a face-milling cutter and an equivalent lathe tool.

different. The effective rake angle α_e and inclination angle i for a face-milling cutter can be found by replacing its angles with the equivalent lathe-tool angles. Thus, in a face-milling cutter, the radial rake angle α_r corresponds to the side rake angle α_s of a lathe tool, the axial rake angle α_a to the back rake angle α_b, and the corner angle C_c to the side cutting-edge angle C_s. Similarly, in a slab mill or plain milling cutter, the radial rake angle α_r corresponds to the velocity rake angle α_v of a lathe tool, and the helix angle h to the inclination angle i.

The normal rake angle α_n can then be found as for lathe tools by using eq. (3), i.e., $\tan \alpha_n = \tan \alpha_v \cos i$.

The effective rake angle α_e can then be obtained from Fig. 13 by using the above values.

Conclusion

A number of investigations by Chance Vought Aircraft have fully established the importance of the effective rake angle α_e in determining optimum cutting-tool geometry, and in some cases spectacular results have been obtained. In fact, it is considered that, by utilizing the techniques described in this report, it is relatively easy to determine optimum cutting-tool geometry directly for most cutting operations and workpiece materials.

Loop Regulation in Rod and Strip Mills

(*Concluded from page 80*)

special transmission devices, such as loop tables or pneumatic loop-lifters, are required between the stands. Instead of using a loop-lifter, the rod can be allowed to hang down between the stands, and, after the rod has been transferred from one stand to the next, the bottom of the loop channel opens and the rod falls in a smooth loop without any mechanical intervention. The speed of the rod gives the loop a certain momentum which stabilizes it as the rod moves from stand to stand.

In installations incorporating a horizontal repeater, the loop indicator can be mounted above the loop or loops, completely independent of the repeater table. The repeater itself can be of entirely conventional type, so that this design of loop indicator makes it an easy matter to introduce automatic control into older rolling mills.

In Swedish rod mills, it is usual to roll only one rod at a time, and the loop can then easily be set in a suitable intermediate position. On the other hand, the regulator can also be used in works where two or more rods are rolled parallel to each other. However, for obvious reasons, only either the largest or the smallest loop can then be controlled. The advantage in the latter case is that the rod will never be stretched between the stands, the length of the external loops then depending on the grooves in the rolls, temperature, etc. On the other hand, if the largest loop is controlled, it is impossible to prevent the smallest loop from becoming so short in certain situations that the rod is stretched, though a certain improvement is always achieved and supervision is certainly better than would be the case if the size of the loop were regulated by hand.

The ASEA loop regulator has been specially designed to deal with the regulating problems of rod and strip mills. It is, however, suitable for use as an indicator in many other situations where the position of an object which is radiating heat is to be measured or regulated, e.g., the acceleration and retardation of reversible hot-rolling mills, or the setting of the shearing length in hot shears. In addition, the position of cold objects can be indicated if they are placed against a background which is radiating heat or light and which may consist of, for example, a fluorescent tube or an electrically heated wire.

Lap-Welding Tubes by Radio-Frequency Currents

By A. S. GELMAN, S. N. MELBARD, V. N. BOGDANOV, P. G. DE-MILLO, and I. A. GRUM-GRZHIMAIL

From *Svarochnoye Proizvodstvo*, Russia, No. 10, 1960, pp. 4–7, 7 illustrations.

NOWADAYS, the use of radio-frequency currents of up to 450 kcs for butt-welding straight-seam tubes of up to 250 mm in diameter (Fig. 1a) is becoming common in Russia, the welding speed being high (up to 60 m/min or even more), and the weld quality excellent. In the case of spirally wound tubes, however, the existing method of submerged-arc welding is not completely efficient and the product is by no means entirely satisfactory. For this reason, a new method of producing spirally wound tubes with bevelled edges by lap-welding has been developed in the U.S.S.R., though it is also adaptable to straight-seam tubes and can probably be used as well for the mass-production of other components made of sheet steel of from 6 to 10 mm thickness.

The principle of the new method, which is at present in the laboratory stage of development, is shown schematically in Fig. 1b, in which two bevelled strips are drawn through two compression rolls (1) with a small angle α between the weld edges. The magnitude of the lap is determined by guide rollers (5) located at each side of the strips in front of and behind the compression rolls (1). At a predetermined distance L from the welding point, two sliding contacts (2) are mounted for supplying welding current to the edges of the strips via a high-frequency generator (3) and a transformer (4). Owing to the proximity effect, which increases with higher frequency, the counter-currents tend to pass in the same direction, so that the current is concentrated on the surface of the edges near the welding point. Penetration of current is very restricted, e.g., 0·04 mm at a frequency of 200 kcs for mild steel at temperatures up to the Curie point and 0·12 mm at higher temperatures. The current gradually heats the weld edges until a fine top layer melts, the film of metal then being pressed out as the strips pass through the compression rolls (1), forming the weld. A welding speed of from 3·5 to 20 m/min was obtained on this experimental rig, the pressure exerted on the strips by the compression rolls being adjustable between 0 and 4000 kg. The strips used were of low-carbon mild steel of from 3 to 6 mm thickness, with the edges bevelled at an angle β (Fig. 1b) of from 38 to 42 deg.

The generator (3) used as the high-frequency supply source (180 to 200 kcs) was rated at 200 kW, and the step-down transformer (4) was located in direct proximity to the mechanical parts of the experimental rig, so as to reduce electrical losses. The current was supplied from the transformer to the sliding contacts (2) via flexible water-cooled leads. The contacts themselves, which were also water-cooled, were molybdenum-tipped and had a working area of 3 × 15 mm, their pressure on the strip being from 5 to 6 kg.

Certain parameters were controlled during the welding process, i.e., the electrical conditions of the generator, the welding speed, the angle α between the pair of strips (for straight-seam tubes) before entering the compression rolls, the size of the lap, the pressure applied by the compression rolls, and the distance L between the sliding contacts and the welding point, maximum heating being obtained when the distance L was 90 mm. With strip of 6 mm thickness, the maximum welding speed obtained on the experimental rig was 5 m/min, the limiting factor being the electrical power available at the workpiece, though this power could have been considerably increased, without increasing the power of the generator, by improving the system used to supply current from the generator.

The angle α between the strips before entering the compression rolls has a considerable effect on welding. Thus, with an angle of 3 deg., electrical contact was established between the edges of the strip at a distance of from 5 to 10 mm from the welding point, leading to unstable heating. In fact, no current at all passed between the actual point of compression of the rolls, and the edges along this section rapidly cooled off, also adversely affecting weld quality. With an angle α of between 4 and 5 deg., heating of the edges was stable, and control over the welding process could be exercised satisfactorily by varying the output of the generator and the welding speed.

Tensile tests showed that optimum results were obtained with the edges bevelled at an angle β of 42 deg. With this angle, a batch of testpieces could be bent through 180 deg., only one specimen failing to pass this test.

A study of the microstructure and macrostructure of the weld showed that there were no visible defects in the tapered part of the weld. However, when the bevel angle β was reduced, the thin edge of the taper became overheated and failed to fuse with the correspondingly thick opposite edge, causing the cross-section of the edges to be heated up less uniformly. In addition, strips could not be successfully welded with a "root face" of less than 1·5 to 2 mm, owing to the overheating and melting of the thick part of the edge. The size of the lap also had a great effect on weld quality, and naturally had to be held constant, a variation of about 0·5 mm leading to a marked deterioration in quality.

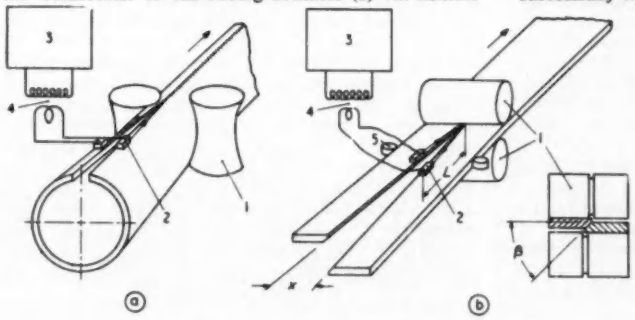


Fig. 1. Schematic arrangement of the principle involved (a) in butt-welding tubes, and (b) in lap-welding tubes by radio-frequency currents.
(1) Compression rolls. (2) Sliding contacts. (3) Generator. (4) Transformer. (5) Guide rollers.

Tests were also carried out on strip of 3 mm thickness with the same distance L and the same angle α between the strips before entering the rolls. In this case, the power consumption of the generator fell and welding speed increased slightly, satisfactory results being obtained with a generator voltage of 9 kV, a current of 9 A, a welding speed of 6 m/min, and a roll pressure of 4000 kg. Uniform fusion across the section of the edges was obtained and no pronounced splashing of the weld metal occurred. It was noticed that the quality of the weld was notably improved by increasing the pressure at the welding point for both the 3- and 6-mm strip.

A study of the microstructure of butt welds not subjected to heat treatment reveals a light decarbonized band with a fine grain structure. Decarbonization may be a consequence of two processes, i.e., burning out of the carbon from the surface layer of the metal, and pressing out of the carbon-enriched easily fusible liquid phase on compression of the welded strips. It was not found possible to determine which of these factors is decisive when welding with radio-frequency currents. The heat-affected zone (3 to 4 mm wide) of the 6-mm strip exhibited large-grain areas of a slightly Widmanstätten structure, as well as sections with a fine-grain structure. The large-grain areas were, however, less pronounced when welding 3-mm strip at high speeds (6 m/min). If welding speeds could be increased still further, there should apparently be no appreciable increase in grain growth.

Tests were also carried out on the lap-welding of 3-mm strip with unbevelled edges. This slightly simplified the welding process and, if such welds are acceptable on constructional grounds, preference should be given to them.

Despite the successful results obtained with this laboratory rig, it should be appreciated that the use of radio-frequency currents for lap-welding bevelled strip for the production of spirally wound or straight-seam tubes of large diameter requires further investigation of certain aspects of the process, including elaboration of the parameters of welding at high speeds, research into the required bevel angle α for steel of up to 10 mm thickness, improvements in the method of supplying the radio-frequency current to the workpiece, and determination of the optimum frequency. Nevertheless, these experiments definitely show that it is possible to use radio-frequency currents to lap-weld mild-steel strip of up to 6 mm thickness with bevelled edges and that tensile tests have established that the weld is as strong as the parent metal. Also, it is practicable to use radio-frequency currents for lap-welding without bevelled edges.

Loop Regulation in Rod and Strip Mills

By W. BENGTSON

From *ASEA Journal*, Sweden,
Vol. 33, No. 6, 1960,
pp. 89–93, 6 illustrations.

FOR many years, the requirements of Swedish rod and strip mills have been very strict with regard to the tolerance limits of the rolled material. As stretching of the material between the roll stands in continuous rolling mills must be avoided if the required tolerance limits are to be maintained along the entire rolled length, this has led, insofar as electrical drive equipment in rod and strip mills is concerned, to supplementing the speed regulation of the drive motors by loop regulation.

Various methods of loop regulation have been developed and have been used reasonably successfully. However, in all these methods, the position of the loop is transmitted mechanically to a potentiometer in the regulating circuit, and this has certain inherent disadvantages. Thus, in a mechanical device which must work intensively, it is difficult to avoid a certain amount of play, which, in cases such as these, may cause difficulties in the closed regulating circuit. The contact roller, which lies against the rod or strip, rotates extremely rapidly, and the problem of providing adequate bearings is a difficult one. Furthermore, when the roller becomes worn, it may cause undesirable marks in the material, while the resistor itself has to be specially made, since it has been found that rheostats of standard type have to be replaced far too often.

To overcome these difficulties, ASEA have developed for the loop a position transmitter which operates without any mechanical contact with the material and is therefore independent of the design of the rolling mill. The only condition is that the material should be visible and have a temperature of at least about 300°C. This is because the transmitter is of a photo-electric type and, in fact, measures the angular co-ordinate of the boundary between a warm object and a cold background, or vice versa.

In the ASEA photo-electric angular co-ordinate locator, a rotating lens or mirror is driven by a synchronous motor, fed at supply frequency. The mirror reflects the radiation from the hot material onto a photocell, sensitive to infra-red rays, causing the cell to emit impulses with a phase position dependent on the angle of incidence of the incoming radiation. The impulses are amplified and transmitted as ignition impulses to a thyratron regulator, the anode voltage of which is in phase with the voltage supplied to the synchronous motor. Consequently, the output voltage of the thyratron regulator is dependent on the position of the radiating loop and can therefore be used as a signal in the control circuit for the speed regulation of the rolling-mill motors. This voltage can also be fed to a voltmeter, giving a reading proportional to the loop position, permitting remote setting of the loop in a suitable position from a control desk located out of sight of the rolling mill itself.

The thyratron amplifier has been designed as a separate unit intended for mounting in the control panel in the machine room, only the photocell with the rotating mirror and the first amplifier stage being located in the rolling mill. In this way, it is easy to fit the separate thyratron unit into various types of control circuits—a considerable advantage when older rolling mills are to be fitted with loop regulation. At the same time, however, it should be noted that, in view of new components now available for electronic amplifiers, it is quite possible that the final amplifier can be made small enough for the equipment to be fitted into a single unit.

Since this loop-position transmitter operates completely without contact with the material rolled, no

(*Concluded on page 78*)

Creep of Resistance Strain Gauges under Static Tension

By C. ROHRBACH and N. CZAIKA

From *Archiv für Technisches Messen*, Germany, No. 287, December 1959, pp. 255–258; No. 289, February 1960, pp. 35–38; and No. 290, March 1960, pp. 55–56; 25 illustrations.

IN electric resistance wire strain gauges, a grid of parallel wires connected in series is bonded to a thin paper base or backing by means of a material such as an epoxy resin, cellulose acetate, or phenol formaldehyde, the whole assembly then being cemented to the surface under test. It is generally accepted that the strain suffered by the wire is strictly proportional at all times to the strain of the transmitting test surface, despite the visco-elastic and non-linear properties of the non-metallic components of the assembly. In this article, however, this assumption is questioned, and it is shown that strain gauges exhibit characteristic creep phenomena which introduce noticeable errors into strain measurements of high precision or of long duration, particularly at elevated temperatures.

Creep and Creep Parameters

Creep $\Delta\varepsilon$ and relative creep $\Delta\varepsilon/\varepsilon$ are defined by

$$\Delta\varepsilon = \varepsilon_0 - \varepsilon_t \text{ and } \Delta\varepsilon/\varepsilon = (\varepsilon_0 - \varepsilon_t)/\varepsilon_0 \quad .. \quad (1)$$

where ε_0 is the strain indicated by the gauge at time $t=0$, and ε_t is the strain indicated at time t. Creep depends on the properties of the backing, adhesive layers, and wire, and these properties, in turn, depend on test temperature, drying, and ageing. Creep also depends on the geometry of the gauge, especially its measuring length and thickness, on the value and sign of the strain imposed, on its loading history, i.e., when and for how long strain was applied previously, and on the pre-tension of the wires. This pre-tension arises during manufacture of the gauge and is also a result of cementing the gauge to the testpiece, heating to the test temperature, and extension of the backing material as a consequence of humidity changes.

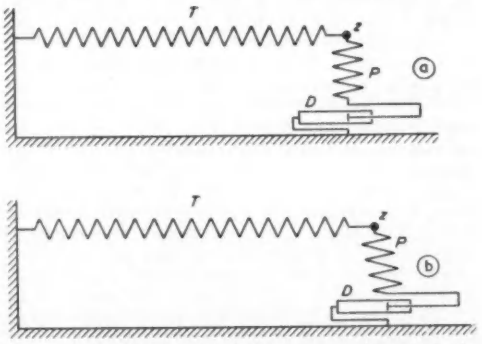


Fig. 1. Mathematical model of a strain gauge, shown (*a*) in the unloaded condition, and (*b*) in the loaded condition.

In this investigation, only the temperature and strain of the testpiece were varied during testing. The geometry and properties of gauges at room temperature are fixed by the choice of gauge used, and each type of gauge tested represented a combination of different geometry and materials. Drying and ageing conditions were kept constant as far as possible. Only tension was applied, as creep in compression is similar to that in tension. Creep was always measured during the first application of load, while pre-tension of the wire was measured, wherever practicable, and was kept as constant as possible by drying the gauge for a long period in a desiccator.

After straining, during which the extension of the gauge wire is proportional to the strain imposed on the testpiece, the backing and adhesive layers slowly yield under the continuing tension of the gauge wire. By means of the mathematical model developed by the authors* and shown in Fig. 1, it has been found possible to develop an equation which gives fundamental and quantitative agreement with results obtained in practice. In Fig. 1, which shows schematically one symmetrical half of a strain gauge, the tensioned wire is represented by a tension spring T of stiffness A, the elasticity of the backing and the adhesive layers by a shearing spring P of stiffness S, joined to spring T at the point z, and their creep behaviour by a dashpot D with a friction constant R.

Relative creep $\Delta\varepsilon/\varepsilon$, referred to the initial strain ε directly after application of the load and proportional to it, is determined by the displacement of the point z and is expressed as

$$\frac{\Delta\varepsilon}{\varepsilon} = 1 - \exp\left[-\frac{t}{r\,(1+S/A)}\right] \quad .. \quad .. \quad (2)$$

where $r = R/S$ is a characteristic of the backing and adhesive materials. The stiffness A of the tension spring T and the stiffness S of the shearing spring P of the model are related to the geometrical and material properties of the gauge in terms of

$$A = 2qE_D/l_0 \text{ and } S = \frac{\lambda\beta}{\delta}\,\frac{E_T}{2\,(1+\mu_T)}$$

where q is the cross-sectional area of the wire, l_0 is its measuring length, and E_D is its modulus of elasticity, λ is the length and β the width of the region (estimated from photoelastic experiments) within which the strain is transmitted from the backing to the wire, and E_T and μ_T are respectively Young's modulus and Poisson's ratio of the backing and adhesive layers considered as a homogeneous unit.

Insertion of these values in eq. (2) gives

$$\frac{\Delta\varepsilon}{\varepsilon} = 1 - \exp\left[-\frac{t}{r\left(1+\dfrac{\lambda\beta l_0}{4\delta q}\,\dfrac{1}{1+\mu_T}\,\dfrac{E_T}{E_D}\right)}\right] \quad (3)$$

If it is desired to distinguish between the paper backing (subscript P) and the adhesive layer (subscript K) bonding the wire to the backing, then $\delta = \delta_P + \delta_K$, so that

$$\frac{\delta}{\varepsilon_T} = \frac{\delta_P}{E_P} + \frac{\delta_K}{E_K} \text{ and } \frac{\delta}{rE_T} = \frac{\delta_P}{r_P E_P} + \frac{\delta_K}{r_K E_K} \quad (4)$$

The very thin adhesive layer between the testpiece and the backing has been ignored in eq. (4), and Poisson's ratio has been assumed to be the same for the backing and adhesive.

* C. ROHRBACH and N. CZAIKA: *Materialprüfung*, Vol. 1, 1959, page 121.

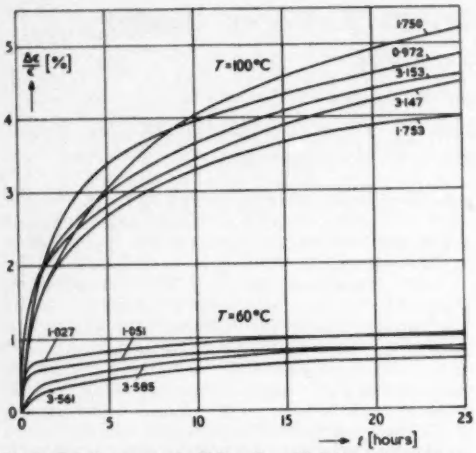


Fig. 2. Relative creep of a Philips Type PR 9210 strain gauge as a function of time at 60° and 100°C under various imposed strains [10^{-3} in./in.].

For the purpose of carrying out experiments on strain gauges, the testpiece was loaded in an oven to a bending strain measured to within $\pm 1\%$ and kept constant to within $\pm 10^{-6}$ in./in. The temperature was held constant to within 0·5°C, and the relative change in resistance of the gauge wire was measured by the deflection method, using a d.c. Wheatstone bridge and dummy gauges for temperature compensation, the error being about $\pm 5\%$. The total error in creep measurement was about $\pm(1 \times 10^{-6} + 5\%)$ for one hour, and $\pm(1{\cdot}5 \times 10^{-6} + 5\%)$ for longer intervals.

The modulus of elasticity E and the creep of the backing and adhesive were measured by comparator methods on thin strips of the respective materials under uniaxial constant tension, the error being about $\pm 5\%$. The temperature dependence of E was measured by the resonance method, in which beams of about $\frac{1}{4}$ in. in depth, $\frac{1}{8}$ in. in width, and $3\frac{7}{8}$ in. in length were freely supported at the nodal points of their fundamental mode and the supports were excited magnetically, the error in finding the absolute value of E by this method being about $\pm 10\%$.

As an example of the results obtained with various measurements, it may be mentioned that tests were carried out on Philips Type PR 9210 strain gauges. The backing thickness δ_P of this type of gauge is estimated as 0·0032 in., and of the adhesive layer δ_K as 0·0008 in. The diameter d of the wire is 0·0008 in., and the measuring length l_0 is 0·964 in., while the photoelastically determined region of transition from the backing to the wire has a length λ of $10d$, and a width β of $7{\cdot}5d$. The measured value of the modulus of elasticity E_D of the wire was $21{\cdot}3 \times 10^6$ psi, independent of temperature, while the modulus E_P of the backing and the modulus E_K of the adhesive layer were 356,000 and 253,000 psi respectively at room temperature.

Eq. (3) predicts that creep is independent of the strain applied to the testpiece, since neither E nor r depends on strain and since the creep of plastics is generally independent of strain. Creep in compression will therefore be opposite in direction but otherwise similar to creep in tension. Fig. 3 shows, in fact, wide straying of the relative-creep curves without any systematic dependence on strain. According to eq. (2),

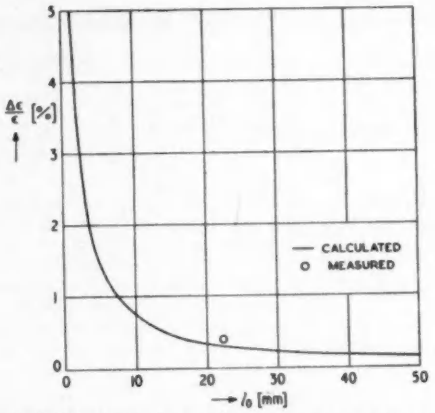


Fig. 3. Relative creep after one hour at room temperature of a Philips Type PR 9210 strain gauge as a function of measuring length.

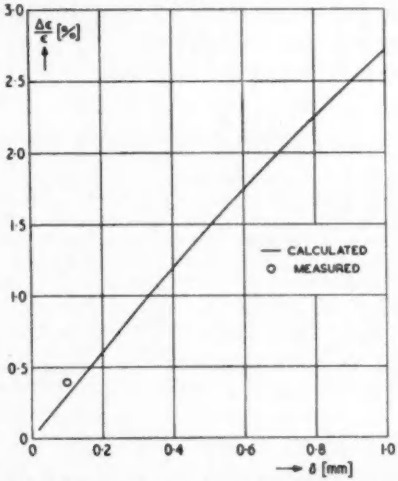


Fig. 4. Relative creep after one hour at room temperature of a Philips Type PR 9210 strain gauge as a function of gauge thickness.

relative creep tends to complete relaxation, i.e., the strain transmitted from the testpiece to the wire should gradually disappear entirely, and the rate of creep (relative creep per hour) should be represented by a straight line as a function of time in a simple logarithmic co-ordinate system. Tests on Philips Type PR 9210 strain gauges at temperatures between 80° and 130°C, with a constant applied strain of about 0·2%, confirm this fairly well. At room temperature, however, there is a deviation from the straight line which can be explained by the fact that the relative creep velocities $1/r_P$ and $1/r_K$ of the paper and adhesive change with time, even under constant tensile loading. If instantaneous values of r_P and r_K are selected to build up the creep curve of a gauge from sections taken over sufficiently small time intervals, the agreement is again satisfactory.

Fig. 3 shows the relative creep after one hour at room temperature of a Philips Type PR 9210 strain gauge with varying measuring length l_0, while Fig. 4 shows the relative creep under the same conditions with varying gauge thickness δ, assuming that δ_P and δ_K increase

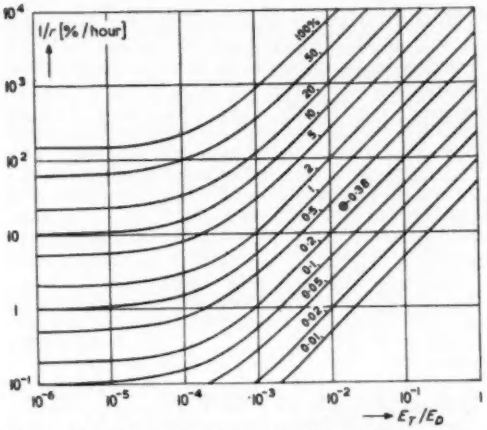


Fig. 5. Curves of equal relative creep after one hour at room temperature as a function of $1/r$ and E_T/E_D for gauges of the same geometry as the Philips Type PR 9210.

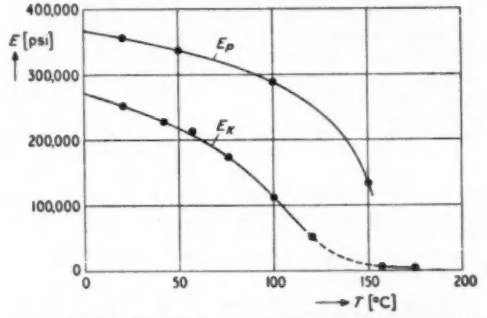


Fig. 6. Moduli of elasticity E_P and E_K for a Philips Type PR 9210 strain gauge as a function of temperature.

proportionately. It will be seen that the measured curves and those obtained in accordance with eq. (3) show good agreement. It should also be appreciated that, according to eq. (3), creep will be reduced if r and E_T are increased, as shown in Fig. 5, in which the point 0·38 measured for the Type PR 9210 gauge at room temperature falls well within the calculated curves.

Creep depends on temperature, because both r and E_T in eqs. (3) and (4) depend on temperature. The change with temperature of E_P and E_K for the materials used in the Type PR 9210 gauge is shown in Fig. 6, the dotted portion indicating a zone of particularly heavy damping in the resonating beam used in the experiment. The change in r_P and r_K with temperature is not known, but plots of the relative creep after one hour as a function of various temperatures show that this change exercises a noticeable influence on the creep of this gauge only at temperatures exceeding 80°C. Below this temperature, the change in creep is mainly due to the influence of the modulus of elasticity E.

Strain gauges of different manufacture show fundamentally the same temperature dependence, creep being mainly connected with changes in the modulus of elasticity of the backing and adhesive. For lacquer-backed gauges, the creep of the backing is of major importance. Hot-setting adhesives are better than cold-setting adhesives of the same chemical type, because cold-setting adhesives are usually less completely cured.

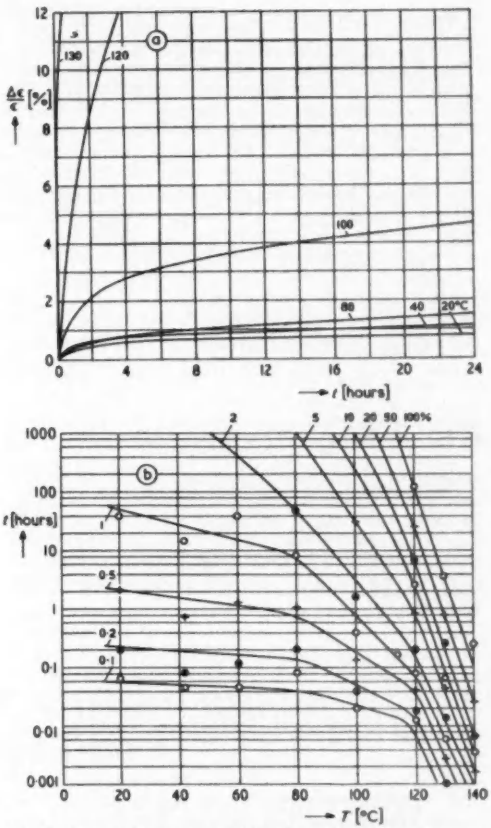


Fig. 7. Creep behaviour of a Philips Type PR 9210 strain gauge, with a measuring length of about 1 in., showing (a) relative creep as a function of time at different temperatures, and (b) the corresponding time-temperature creep diagram.

At temperatures above 120°C, both types exhibit similar creep behaviour.

It should be noted that eq. (3) does not account for the observed fact that previous straining appreciably affects the creep behaviour of the gauge. A definite relationship between creep and the pre-tension of the gauge wire, measured as between −0·04% and +0·07% in Type PR 9210 gauges, could not be established experimentally. It is possible that straying of the creep curves is due primarily to differences in pre-tension.

In addition to Philips strain gauges, tests have been carried out on Hottinger and Huggenberger gauges to determine their creep behaviour as a function of time at different temperatures, the other parameters being kept as constant as possible. In all cases, the mean curves of relative creep obtained show deviations from the results of a number of individual tests, these deviations sometimes reaching as much as ±50%, and being larger at lower temperatures than at higher temperatures.

From these curves of mean relative creep, an example of which is shown in Fig. 7a for the Philips Type PR 9210 strain gauge, time-temperature creep diagrams can be constructed, these diagrams indicating the total relative creep after a given time at a given temperature. If, therefore, a certain value of total relative creep is

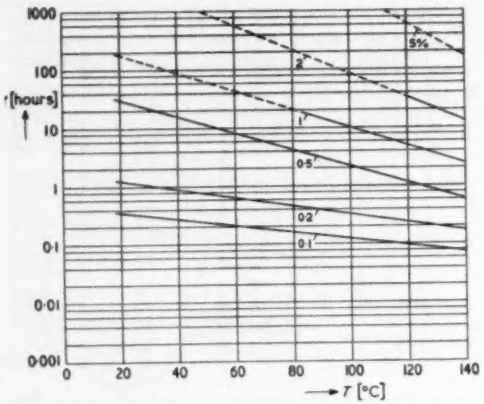


Fig. 8. Time-temperature creep diagram of a Philips Type PR 9212B strain gauge, with a measuring length of about $\frac{1}{16}$ in., at temperatures up to 140°C.

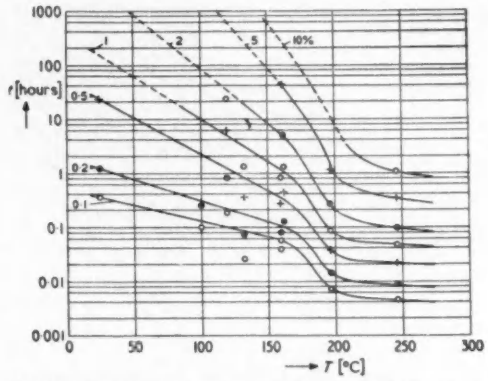


Fig. 9. Time-temperature creep diagram of a Philips Type PR 9212B strain gauge, with a measuring length of about $\frac{1}{16}$ in., at temperatures up to 275°C.

assumed to be permissible, these curves will indicate the time and temperature that must not be exceeded. Fig. 7b shows these curves corresponding to the curves in Fig. 7a for the PR 9210 gauge, while Fig. 8 shows the curves for a Philips Type 9212B gauge at temperatures up to 140°C and Fig. 9 for the same gauge at temperatures up to 275°C.

Since changes in the values of E_K, E_P, r_K, and r_P with temperature are usually not known, and since the values of r are constant only for about one hour at a time, eq. (3) cannot be generally used to extend the application of these diagrams quantitatively, e.g., to similar gauges with a different measuring length l_0. However, eq. (3) does reflect the trend of the influence of the different parameters involved.

Non-Destructive Methods of Testing Small-Bore Tubing

By J. R. GRIEVE and A. M. EOUNDS

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FOR producers of small-bore tubing, particularly where its application in such critical items as atomic reactors and missiles is concerned, non-destructive testing is essential. Furthermore, several types of tests must be available, as it must be understood that no one test is versatile enough to supply all the required information. It is therefore the object of this article to compare a number of non-destructive test methods in terms of their ability to detect imperfections which are serious enough to warrant rejection of the tubing. These test methods can be divided into different types, i.e., visual, eddy-current, dye-penetrant, magnetic-particle, ultrasonic, radiographic, and hydrostatic, and it is only by means of a proper combination of these tests that full information can be obtained.

Visual Tests

The visual examination of tubing, either with the naked eye or, more generally, under magnification, is common practice, using a magnifying glass to inspect the outside diameter and an endoscope or "boroscope" to examine the inside diameter. Both these tests require a considerable amount of inspection time and are limited to finding surface defects. At the same time, their effectiveness depends, to a large degree, on the skill and conscientiousness of the inspectors. Endoscopic examination, in which the tubes are rotated while the instruments traverse them, are particularly slow and tedious, and require a high degree of operator skill.

Another limitation in endoscopic testing is the size of the internal diameter which can be inspected (0·140 in. minimum) and the distance that the instrument may be inserted (about 3 ft maximum for tubing of about $\frac{3}{16}$ in. i.d., or about 20 ft maximum for larger tubing). In practice, endoscopes are often used in conjunction with eddy-current tests to determine whether the area which has caused an indication is really defective.

Eddy-Current Testing

At present, eddy-current testing—also known as electromagnetic inspection—offers the best combination of advantages for examining small-bore tubing. For small-bore tubing, which encompasses a variety of sizes, wall thicknesses, materials, tempers, and surface conditions, a single-channel, single-frequency tester is inadequate. Equipment with two control units—each of which has two flaw detection channels, one property-variation circuit, and one frequency-selection unit—has been found most effective. Twenty-one different frequencies, from 1·8 to 700 kcs, can be selected for test purposes. With this equipment, it is possible to detect a number of variations from normal and to ascertain their position, character, and relative size, to detect changes in chemistry and tubing size, and to inspect simultaneously for surface and subsurface defects.

One problem in connection with the use of any eddy-current testing equipment is to determine whether the defects it picks out make the tubing rejectable or not. So far, the best answer has been the use of standard reference tubes fabricated with notches of predetermined size on the outside surface in a longitudinal direction near the centre of the tube. The inspection is adjusted in such a manner that it gives a clear indication of the presence of any defect as large as or larger than the notched standard. If the tubing has a defect which gives a signal equal to or better than that for the notched standard, the tubing is classified as rejectable. The most practicable standard has been found to be a notch 0·004 in. deep on tube walls 0·040 in. thick and greater, and a notch cut to 10% of wall thickness on walls less than 0·040 in. thick. The tolerance on depth of the reference notch is held to +0·0000 in., −0·0005 in.

The advantages of eddy-current testing are many. Thus, although the cost of the original equipment is comparatively high, it can be operated with average skill and is very fast. Ordinarily, tubing is tested at about 250 fpm, but the speed can be increased to 1000 fpm if vibration can be kept within limits.

Despite its high speed (which permits mass-production inspection), the test is very sensitive. It will detect numerous types of imperfections (including pits, gouges, cracks, inclusions, weld defects, carburization, surface oxide, porosity, roughness, corrosion, laps, and embedded particles) which may be present in tubing. Particularly useful in revealing tight discontinuities, it will detect such imperfections on the outside or inside diameters of tubing from the smallest size up to 3 in. o.d. with walls ½ in. thick. Eddy-current testing has also been used to detect changes in outside and inside diameters and wall dimensions (though it cannot tell which dimension has changed), and in the chemical composition of the material.

To set eddy-current testing in its proper perspective, however, it is well to point out its limitations (most of which are also found in other non-destructive tests). First and foremost, it will not measure the depth of defect (the principal factor in detecting rejectable tubing), nor can it clearly differentiate between the type of flaws. Because the method is highly sensitive, it responds to a large number of variables, such as grain size, stress concentrations, minor inclusions, changes in magnetic properties, and small changes in dimensions, none of which is usually considered a cause for concern. An added complication is that a given variable may be perfectly acceptable in one application but cause for rejection in another. Eddy currents will not tell whether the defect is on the outside or inside diameter (except on heavy-wall tubing or by means of dual-frequency equipment), or in the wall of the tubing. Also, natural defects do not necessarily correlate with artificially produced defects of rejectable level.

Despite these minor drawbacks, eddy-current testing is, in the authors' opinion, the best method of production inspection of small-bore tubing for critical applications. Admittedly, however, certain improvements are desirable. For instance, what is most needed at present is better agreement between the vendor and customer on acceptability standards. There is also a requirement for eddy-current machines which will retain their sensitivity without background noise and which will distinguish between a wide, shallow defect and a narrow deep defect, as present equipment is sensitive only to the relative volume of a defect.

Dye-Penetrant Tests

If non-destructive tests could be rated by their all-round usefulness, dye-penetrant testing would rank second to eddy-current inspection. Actually, it is quite different from eddy-current testing, since the human eye, rather than a machine, is used to detect the flaw.

There are two kinds of dye-penetrant tests, i.e., visible and fluorescent. The visible test uses only a red dye, while the fluorescent test uses a fluorescent dye and requires ultraviolet light.

In the visible test, the red dye is dissolved in a light oil of such viscosity and surface-wetting nature that it is rapidly sucked into tight cracks and crevices. After the excess dye is wiped off with a solvent, the tubing is coated with a white colloidal suspension known as a developer. The red dye oozes from the flaw, and bleeds through the white developer, making the defect readily visible.

If more sensitivity is desired, the fluorescent test is used. Though its application is somewhat more complicated than with the visible method, the action is similar, the fluorescent dye seeping from the flaw and bleeding through the developer. When the tube is examined under ultraviolet light, the defect glows. Though this test gives greater contrast than the visible dye-penetrant test, the latter is sufficient for most requirements.

Because of their extremely high sensitivity, both tests will often pick up defects missed by eddy-current or ultrasonic inspection. Sometimes this is a disadvantage, since they will show imperfections which may not necessarily be classed as defects.

As for equipment, only the simplest is required for the visible test, while equipment for the fluorescent test is not costly compared with that required for some of the other non-destructive tests. There is no limit as to the type of metal the method will test, except that porous metals will give false indications. Furthermore, only average skill is required in operation.

The principal limitation of dye-penetrant tests is that they are slow. Consequently, they are expensive, unless they are part of an automatic production unit. Moreover, dye penetrants can be used only to detect flaws on the outside diameter of the tube, because the dye cannot penetrate into defects below the surface. Finally, on small tubing, dyes show only that a flaw is present, not how deep it is. Nevertheless, as stated before, the dye-penetrant test is a good companion to the eddy-current test, and both should be used whenever permitted by inspection-cost allowance.

Magnetic-Particle Testing

When a magnetic field is induced around a piece of ferromagnetic metal tubing, a north magnetic pole is formed at one end and a south pole at the other. At the same time, any cracks in the tubing, whether on the surface or beneath it, also form magnetic poles. Thus, when the magnetized tubing is coated with fine particles of magnetic iron, the particles cling to the defect. Appearing as black lines, the size of the particle build-up gives an indication of the severity of the defect. Here again, as in the eddy-current test, the method is volume-sensitive, not depth-sensitive.

Sometimes, when the contrast is not sufficient, the testpiece is dipped into a fluorescent solution and then washed clean. Since particles of the fluorescent iron powder remain in the tiny cracks or flaws, they show up when the tubing is examined under ultraviolet light.

The magnetic-particle test, which is not as sensitive

as the dye-penetrant tests, is used on large metal surfaces more often than on small tubing. Also, it is limited to metals which can be magnetized, and testpieces must often be demagnetized after the test is made. As with dye-penetrant testing, the method is comparatively slow and requires some skill. However, it is useful in detecting flaws on or just beneath the surface, and gives some indication of the size of the defect.

Ultrasonic Testing

In ultrasonic testing, sound waves of extremely high frequency are directed through the tubing by a quartz-crystal transmitter. The surface of the tubing acts as a mirror for the sound waves, bouncing them back and forth between the surfaces of the outside and inside diameters. To inspect tubing, the "shear" technique is used, in which the pulse is introduced at an angle and echoes back and forth between the outer and inner surfaces around the circumference of the tubing. If there are no cracks or flaws in the tubing, the sound wave ends up as a straight line on a cathode-ray oscilloscope; if there are flaws, they show up as a jagged line or "pip".

In performing the test, the tubing is revolved while the pulse generator moves along its length. In another version of the test, the tubing is immersed in a tank of water, with the water acting as a couplant. For tubing, the latter method seems to give better results than contact ultrasonic testing, apparently because there are fewer false indications.

Ultrasonic testing has an advantage over eddy-current testing (as now developed) in that it can be used for either magnetic or non-magnetic metals. Like eddy currents, ultrasonics will detect defects on the outside and inside diameters and subsurface defects. Considerable skill is required to set up the equipment, but the interpretation of results is not subject to the operator's judgment if an alarm circuit is used.

With regard to its drawbacks, ultrasonic testing involves the use of expensive equipment and is fairly slow. Also, it cannot test tubing satisfactorily in the smaller range of sizes. In fact, if the tubing is less than $\frac{1}{4}$ in. o.d. or has a wall thickness of under 0·049 in., ultrasonic testing is considered to be impracticable. Other disadvantages of ultrasonic testing are that diagonal laps which parallel the sound wave can be missed, that surface reflections can also cause interference, and that the location of the defect, either on the outside or inside diameter, cannot be determined. If non-magnetic materials are being tested, the authors' experience has shown that eddy-current testing is superior to ultrasonic testing.

Radiographic Testing

In radiographic testing, X-rays are generally used, but radioactive isotopes such as cobalt-60, iridium-90, and thorium-170 have also been employed, these, isotopes emitting gamma rays, which give greater penetration.

Considerable skill is required to interpret the radiographic film. As a check on the adequacy of the radiograph, a standard testpiece called a penetrameter is often used. The radiographic technique being considered satisfactory if the outline of the penetrameter shows used clearly in the radiographs. Film strips showing natural or artificial defects are used as standards to aid in evaluating radiographs.

Normal radiographic checking involves placing the film in contact with the inside surface of the tube. Space is a limitation, since film cannot be satisfactorily inserted and held in place if the inside diameter is less than $\frac{1}{4}$ in. When smaller sizes are to be tested, the only practical approach is to place the tubes on flat X-ray film and take three pictures at 120-deg. angles of rotation. This has the inherent drawback of attempting to interpret effects of penetration through varying wall thicknesses. Other disadvantages include the high cost of the equipment, the need to shield personnel from radiation, and possible interpretation of defects in the film as defects in the metal.

Radiographic testing is valuable in finding gross defects in large sections of metal but, in the authors' experience, has little application in testing small tubing because of its high cost, compared with the unit value of the product being examined.

Hydrostatic Testing

Hydrostatic testing is an internal pressure test which, strictly speaking, is not really a non-destructive test since it may weaken, without actually bursting, a tube containing defects. It is useful for finding open, through-wall defects, because the oil or water used will leak through.

Generally, all tubing for pressure applications including super-pressure, hydraulic, and capillary tubing, is given a hydrostatic test but this is a capability test only as it will not tell accurately what will happen to the tube in service, because the tubing cannot be tested for that length of time. It is limited to finding defects which penetrate the tubing wall or which will penetrate it when pressure is applied. The cost of the test is comparatively high because of the slow rate of testing. Two testers, one supplying up to 20,000 psi pressure with oil and one up to 40,000 psi pressure with water, should meet nearly all hydrostatic testing requirements for small-bore tubing.

Conclusion

It will be noted, from this discussion that no non-destructive tests (except hydrostatic testing) have been developed specifically for small tubing. Instead, non-destructive tests used for other forms and sizes of metal have been adapted, and this is the basic weakness of the tests now in use. In these tests, certain physical phenomena—such as sound waves, magnetic currents, and X-rays—are affected by the total size of the flaw (length, width, and depth), whereas the seriousness of a tubing flaw is almost always evaluated by its effect on the tubing wall, i.e., its depth. When a flaw is found, the usual practice is to file it off the tubing, if it is on the outside surface. If the tubing is still within wall-thickness tolerance limits, it is accepted; if not, it is rejected. Obviously, much time could be saved by a test which would quickly and accurately measure the depth of the flaw and determine at once if it is a rejectable defect.

Non-destructive testing is an extremely valuable tool in maintaining quality control, but it is not an end in itself. Rather, it serves to point out questionable features which may be investigated further by destructive tests. If there is one outstanding conclusion that the authors have drawn from their experience in the non-destructive testing of tubing, it is that no one test is sufficient in itself. None of them alone will give the complete answer for all types of tubing under all conditions.

Finally, it may be said that, until such time as a universally acceptable non-destructive test for tubing can be established, the most satisfactory answer to the problem is to set up standards for the tests now available and establish mutual agreement between the vendor and user as to exactly what is required of the tubing, what constitutes a defect (rejectable imperfection), and what does not.

The Effect of Swirl Timing on Combustion in Diesel Engines

By F. NAGAO, H. KAKIMOTO, and M. HIRUKAWA

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Vol 3, No. 11, 1960,
pp. 378–385, 9 illustrations.

THE importance of an air swirl for mixture formation and combustion in diesel engines is well known, and the relation between swirl intensity and combustion has been the subject of many investigations, notably by Ricardo[1]. However, little information has been available on the effect of varying the timing of swirl generation, and the purpose of this paper is to provide experimental data on this subject.

Indirect-injection engines can operate with various swirl timings. In the swirl-chamber engine, swirl is created before fuel injection. In the conventional pre-chamber engine, swirl is created in the main combustion chamber almost at the same time as the fuel is injected. In the Lanova air-cell engine[2], and in the MWM balanced-pressure precombustion engine[3], swirl is created after fuel injection. Each of these three main types has its typical combustion characteristics, which determine the optimum combustion conditions obtained with each system.

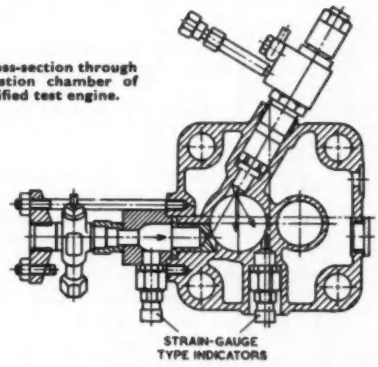

Fig. 1. Cross-section through the combustion chamber of the modified test engine.

The main tests of the present investigation were made on a modified Yanmer ST-95 single-cylinder water-cooled four-stroke diesel engine, a cross-section through the combustion chamber of this engine being shown in Fig. 1. The engine was provided with two separate Bosch-type injection systems with plunger diameters of 6·5 and 7·0 mm respectively, one nozzle being arranged to inject into the auxiliary chamber, and the other into the main chamber. Two types of main-chamber injector were used, i.e., one with one hole of 0·4 mm diameter, and the other with two holes of 0·25 mm diameter. Injection timings and fuel deliveries were adjustable independently, according to the relative conditions under investigation.

For operation with precombustion swirl, the fuel was injected solely into the auxiliary chamber, the rise in pressure in this chamber creating an outflow of gas and producing a swirl in the main chamber, which was situated below the exhaust valve. The engine could also be operated as an air-cell engine by altering the relative operating conditions of the two injectors. The dimensions of the auxiliary combustion chamber were not specially chosen for either operating system, but were a suitable compromise between optimum conditions for the two systems. In all the tests, the fuel used was a heavy oil with a specific gravity of 0·85 and a cetane number of 45.

Cylinder pressures were indicated by means of pressure pick-ups of the strain-gauge type, with a natural frequency of 35 kcs, operating in conjunction with transistorized amplifiers. Electromagnetic oscillographs were used for the recordings. In addition, the structure-borne noise of the engines was recorded, and the state of the exhaust gas was determined. Measurements were also taken of needle lift, exhaust temperature, etc. A modified cylinder head was employed for high-speed photography of the various phases of the combustion processes.

Injection Timing

The swirl created in the main chamber depends on the quantities of fuel injected and on the injection timings of the two injectors. In a preliminary test, the quantities of fuel injected into both chambers were kept approximately equal, and the timing of the fuel injected into the auxiliary chamber was varied from about 15 deg. before top dead centre to 10 deg. after T.D.C. for three different injection timings of the fuel sprayed into the main chamber. The results, using the two-hole main injector, are given in Fig. 2, and show that the specific fuel

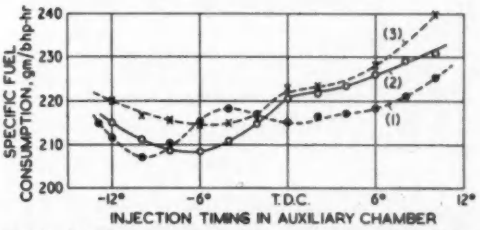

Fig. 2. Specific fuel consumption as a function of auxiliary-injection timing, with 5·5 kg/cm² bmep and an engine speed of 1250 rpm, and main-injection timings of (1) −10·5°, (2) −7°, and (3) −3° T.D.C.

consumption is improved when the swirl created in the main chamber during a certain period after the auxiliary injection occurs immediately after the main injection. There is another, but less pronounced, decrease in fuel consumption when the auxiliary injection takes place near T.D.C.

Proportion of Fuel Injected into the Auxiliary Chamber

Increased swirl intensity in the main chamber is obtained by increasing the proportion of fuel injected into the auxiliary chamber, but the heat losses and throttling losses in the connecting passage also become greater. The fuel proportions must therefore be chosen in such a way that the improvement in combustion due to a more intensive swirl will not be counterbalanced by

heat and throttling losses, also bearing in mind that the effect of swirl on combustion is mainly dependent on the timing of the auxiliary injection. Furthermore, retarded injection increases the thermodynamic loss of the engine cycle, and this loss becomes particularly noticeable when a large proportion of the fuel is injected into the auxiliary chamber.

To determine the effect of different fuel proportions two different sets of tests were carried out. In the first set of tests (Fig. 3), the initiation of main-chamber injection, using the two-hole injector, was kept constant at −10·5° T.D.C., while the timing of the auxiliary injection was varied. Considerably improved combustion was obtained when a small proportion of the total fuel was injected into the auxiliary chamber, specific fuel consumption being reduced over a wide range of timings for the auxiliary injection (from −20° to +10° T.D.C.). Increased proportions of fuel into the auxiliary chamber narrowed the range of allowable timings for auxiliary injection.

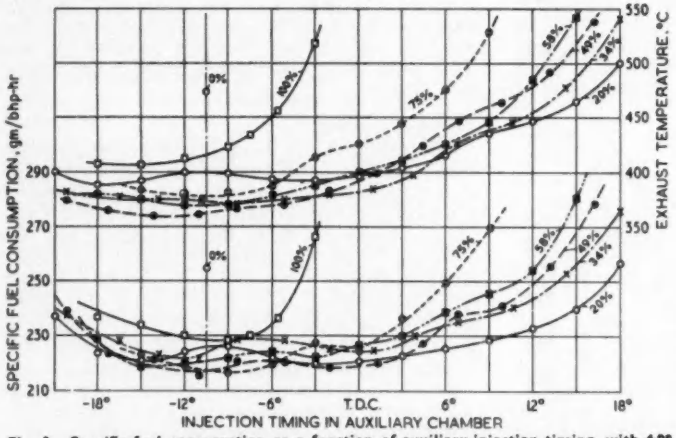

Fig. 3. Specific fuel consumption as a function of auxiliary-injection timing, with 4·98 kg/cm² bmep at 1250 rpm, for different ratios [%] of auxiliary to total fuel injection.

In the second set of tests (Fig. 4), auxiliary injection was kept at a constant timing of −10° T.D.C., while the timing of the main-chamber injection was varied. The results again showed a marked improvement in combustion for small proportions of fuel injected into the auxiliary chamber. The allowable range of timings for main-chamber injection depended on the fuel proportions.

The test results given in Figs. 3 and 4 show that low fuel consumptions can be obtained over wide ratios of auxiliary to main injection (from 20% to 75%) if suitable timings are used. This indicates that the increased heat

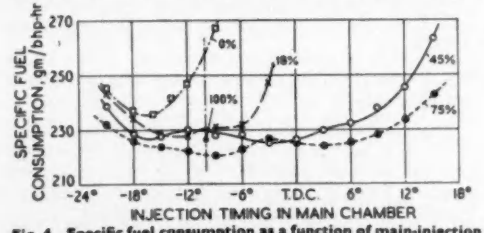

Fig. 4. Specific fuel consumption as a function of main-injection timing, with 4·98 kg/cm² bmep at 1250 rpm, for different ratios [%] of auxiliary to total fuel injection.

and throttling losses with high proportions of fuel injected into the auxiliary chamber are compensated by considerable improvements in combustion. Evidence of the fact that the heat losses are then also increased is given in Fig. 3, which shows, for example, that for 75% of the total fuel sprayed into the auxiliary chamber the exhaust temperature is appreciably higher than for the lower percentage giving the same fuel consumption.

Relative Directions of Fuel Injection and Air Swirl

Nozzles injecting at different angles into the main chamber were used to study the effects of varying the direction of fuel injection in relation to air swirl. Fig. 5 shows curves of specific fuel consumption and exhaust discoloration obtained with different auxiliary-injection timings and with four different directions of main-chamber injection, Nos. I, II, and III corresponding to the use of the injector with one hole of 0·4 mm diameter, and IV to the injector with two holes of 0·25 mm diameter. In these tests, in which the engine speed was 1250 rpm, a fixed quantity of fuel was injected into each chamber, i.e., 15·6 mgm/stroke for the auxiliary injector, and 16·4 mgm/stroke for the main injector at −10·5° T.D.C.

In arrangement I, with injection in the downstream direction, fuel consumption reached a low value for simultaneous injection into both chambers, but increased gradually with retarded timing for the auxiliary injection. In arrangement II, with injection aimed at the centre of the combustion chamber, fuel consumption reached its lowest value with almost simultaneous injection into the two chambers (−12° T.D.C. into the auxiliary chamber and −10·5° T.D.C. into the main chamber). In arrangement III, in which injection was directed upstream into the air swirl, no improvement in combustion was obtained and discoloration of the exhaust was increased, particularly with simultaneous injection into both chambers (about −10° T.D.C.). The best conditions as regards minimum exhaust discoloration were provided by arrangement IV, using two jets of fuel aimed at an angle of 30° on both sides of the centre of the main chamber. In this case, the fuel-consumption curve had two minima, corresponding to auxiliary-chamber injection timings of about −10° and +6° T.D.C.

The tests showed that exhaust discoloration could be reduced by retarding the timing of auxiliary injection, indicating that complete combustion can be obtained by creating an efficient swirl after ignition has occurred in the main chamber. For this purpose, retardation of auxiliary injection was allowed at the expense of some increase in the thermodynamic losses of the cycle. These results show that an improvement in specific fuel consumption is not always indicative of improved combustion conditions such as are denoted by the state of the exhaust.

Cylinder-Pressure Diagrams and Rate of Pressure Rise

Cylinder-pressure diagrams obtained from numerous tests, using different auxiliary-injector timings, were

evaluated, the results being shown in Fig. 6. It will be seen that, with an excessive advance of auxiliary-injection timing, ignition is initiated in the auxiliary chamber, and the peak pressure in the main chamber is higher than that in the auxiliary chamber. When injection into the auxiliary chamber is retarded, the ignition timings and peak pressures of the two chambers tend to have similar values. The peak pressures then reach a maximum at about −13° T.D.C., when ignition occurs in the two chambers simultaneously. With further retardation, ignition in the main chamber commences earlier, and the main-chamber peak pressure becomes lower than the peak pressure in the auxiliary chamber. The variation in the rate of pressure rise in the main chamber shows a similar trend, and reaches a relative minimum at about −13° T.D.C.

It is considered that these phenomena are due to the outflow of gas from the auxiliary chamber, owing to simultaneous combustion in the two chambers. With auxiliary injection retarded further to about −12° T.D.C., the peak pressures in both chambers and the rate of pressure rise in the main chamber tend to increase slightly, after which these values decrease rapidly, finally reaching constant values after T.D.C., as shown in Fig. 6.

Fig. 6 also shows that the specific fuel consumption reaches equally low values for auxiliary-injection timings of −10° and +6° T.D.C. The retarded timing, however, has the advantage of producing a considerable reduction in the rate of pressure rise, lower peak pressures in both chambers, and a clearer exhaust. In contrast, advanced auxiliary-injection timing gives rise to excessive swirl during the ignition delay period in the main chamber, with higher peak pressures, higher rates of pressure rise, and a darker exhaust.

The curve of combustion noise in Fig. 6 shows the structure-borne noise of the engine and, for the range of advanced values of injection into the auxiliary chamber, follows the variations in the curve for the rate of pressure rise, whereas, for retarded auxiliary injection, it shows several minima and maxima. It can also be noted from Fig. 6 that, with further retardation of auxiliary injection, the exhaust temperature rises, and so does the specific fuel consumption.

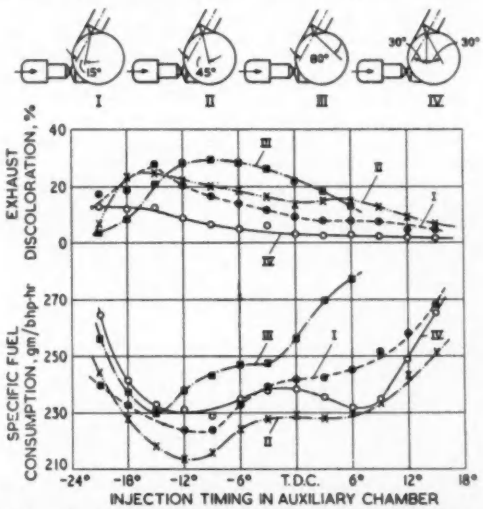

Fig. 5. Specific fuel consumption and exhaust discoloration as functions of auxiliary-injection timing, using four different directions of main-chamber injection.

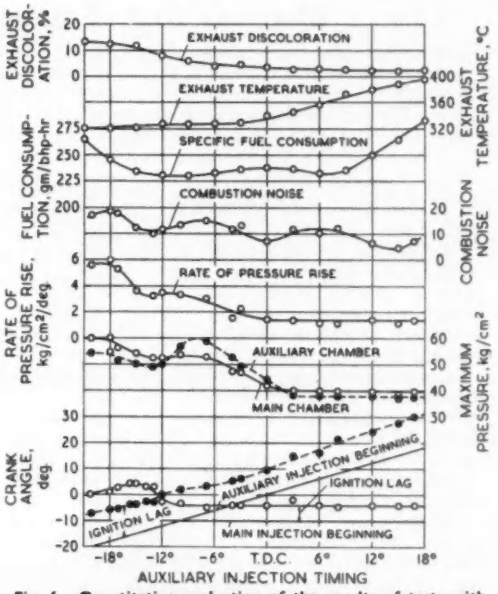

Fig. 6. Quantitative evaluation of the results of tests with various auxiliary-injection timings.
Engine speed: 1250 rpm.
Main injector: Two-hole type, 0·25 mm diameter, at −10° T.D.C., 16·2 mgm/stroke.
Auxiliary injector: 15·4 mgm/stroke.

High-Speed Photography of Combustion Processes

A further investigation into the development of combustion was made by means of high-speed photography. For this purpose, it was found convenient to use the reconstructed cylinder head of a two-stroke loop-scavenged engine, which was redesigned so as to have an auxiliary chamber, as well as the main chamber, the top portion of the head being provided with a glass window.

Photographs of combustion were first taken with the engine operating with direct injection into the main chamber only. In this case, the development of the flame pattern showed that a small quantity of fuel was brought into the auxiliary chamber by the air stream during the compression stroke. However, this small amount of fuel had a considerable influence on mixture formation and combustion in the main chamber, since the weak outflow of gas commenced around +25° T.D.C.

In the case of combustion with dual injection, the outflow of flame from the auxiliary chamber occurred at about +5° T.D.C., i.e., some time after the beginning of ignition in the main chamber. The time available for the development and disappearance of flame in the main chamber was shortened considerably, even though the

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Machining Tungsten with Carbides

By F. J. McGee

From *The Tool and Manufacturing Engineer*, U.S.A.,
Vol. 45, No. 4, October 1960,
pp. 79–82, 5 illustrations.

Of the common metals, commercially pure tungsten is the hardest, densest, and strongest, and has the highest melting point (6152°F), making it an attractive material for aircraft and missile fabrication. At the same time, its brittleness and abrasiveness make tungsten one of the least attractive materials from a machining standpoint. If a sheet of 0·05-in.-thick tungsten is dropped, it shatters like glass, while a 3-in. bar of tungsten fractures like ice if it is chucked too tightly.

Despite these adverse properties, research work has demonstrated that it is possible to machine tungsten parts and that pure tungsten, generally considered unmachinable by conventional methods other than grinding, can be cut by silicon carbide cut-off wheels and tungsten carbide tools, while blanking and shearing are possible in the temperature range between 500° and 700°F.

In the course of this research, several machining methods were attempted and sometimes abandoned. Sawing flat stock, for example, was not successful. Various blades, speeds, and bandsaws were tried out, and it was found that high-speed-steel saw blades dulled rapidly, creating a crushing action which splintered the workpiece. Cut-off wheels, however, produced satisfactory cuts, the best results being obtained with soft silicon carbide wheels as, in some instances, hard wheels would not cut. Of the speeds and feeds used, a feed of from 1 to 1·5 ipm and a speed of 30 fpm worked moderately well when both sides of the wheel were flooded with water-soluble coolant.

For producing flat shapes, shearing and blanking were tried. No success was obtained when these operations were attempted at room temperature, but acceptable cuts were made when the tungsten sheet was heated to between 500° and 700°F. Above 700°F the sheet became brittle, tarnished, and oxidized. There is apparently a zone between 700° and 1500°F in which tungsten loses its ductility. Blanking was successful only when the tungsten was made ductile by heating.

When turning tungsten bar stock, high-speed tools failed almost instantaneously, depths of cut in the neighbourhood of 0·050 in. causing the workpiece to chip and flake. A carbide lathe tool gave satisfactory results with a side rake angle of 20 deg., and a nose radius decreased to a point. By roughing at a speed of 70 fpm, with a 0·005-ipr feed, and a 0·050-in. depth of cut, and finishing at 70 fpm, with a 0·001-ipr feed and a 0·020-in. depth of cut, reasonable tool life and excellent finishes were obtained. It was discovered that, because of the tendency of tungsten to crumble, all cuts except light finishing cuts should be made working towards the centre of the workpiece. Large chamfers should be used on the ends of the piece; otherwise, the ends of the workpiece tend to chip severely.

In drilling tests, it was found that drilling was seven times more successful at 600°F than at room temperature, using $\frac{1}{16}$-in. high-speed-steel drills in 0·050-in. tungsten sheet. However, the holes drilled at 600°F shrank undersize when the sheet returned to room temperature. Carbide-tipped drills were only slightly more successful. Despite many attempts, only two $\frac{1}{16}$-in. holes were obtained when drilling 0·020-in. tungsten sheet at room temperature. Unless the sheet was backed up, excessive chipping at drill break-through resulted. Because of these disappointing results in drilling tests, it is probably best to make holes by electrical-discharge methods.

Boring was accomplished with little trouble. As in turning, it is advisable to work from the end towards the centre. A standard carbide-tipped boring bar, with a 45-deg. lead angle, a 0·010-in. nose radius, and a 0-deg. side rake, was used to open two holes from 0·375 to 0·875-in. diameter. Roughing was at 75 fpm, with a 0·0015-ipr feed and a 0·020-in. depth of cut. Finishing was also carried out at a speed of 75 fpm, but with a feed of 0·0002 ipr and a depth of cut of 0·002 in.

Tapping was unsuccessful. An attempt was made with both the workpiece and the taps heated to 500°F, a set of two taps being used to limit metal removal and cutting forces. The first pass left an unsatisfactory thread, but it was hoped that the threads could be cleaned up with the second tap. Shattering of the workpiece resulted, but it is not known whether the cutting forces were too great or the lead angle lost. Even if a full thread could be tapped, the thin thread sections produced would be too delicate to be of real use. Partial internal and external threads were produced by thread chasing. To avoid the crumbling of tungsten at the thin end thread sections, the workpiece was supported by placing it between aluminium discs. For external threads, the discs were clamped onto each end of the tungsten piece by a bolt running through their centres. The discs were turned to the same outside diameter as the tungsten piece. For internal threading, the workpiece was clamped between two flange-like aluminium discs and held by three bolts passing through holes 120 deg. apart on the flanges and far enough from the centre-line to clear the outside diameter of the workpiece. The discs were machined to the same inside diameter as the workpiece.

With the ends of the workpiece thus protected against crumbling of the outermost thread sections, external threads were started in one aluminium disc, carried across the tungsten workpiece, and completed in the second aluminium disc. With this set-up, 75% threads were produced by a standard carbide threading tool having a 0-deg. back rake and a 0-deg. side rake. A cutting speed of 57 fpm was used, with a 0·005-in. depth of cut for roughing and a 0·002-in. depth for finishing. Internal threads were started in one of the aluminium discs, carried through the workpiece, and completed in the second disc. A standard carbide internal threading tool was used to produce 60% threads.

(*Concluded on page 105*)

ERRATA

In the Survey on "Diecasting" in our issue of December, 1960, the following corr ections should be made:—

Page 83, *Fig.* 13: The particular carburetter body illustrated in Fig. 13 was diecast in LM-2 aluminium alloy, *not* LM-4 as indicated in the caption and in the text.

Page 108, *last line*: ". . . U.S.A. by the Madison-Kipp Corporation, are produced . . ." *should read* ". . . U.S.A. by the Madison-Kipp Corporation, and in England by Wm. Coulthard & Co. Ltd., who are world licensees with the exception of the U.S.A. and Canada, are produced . . ."

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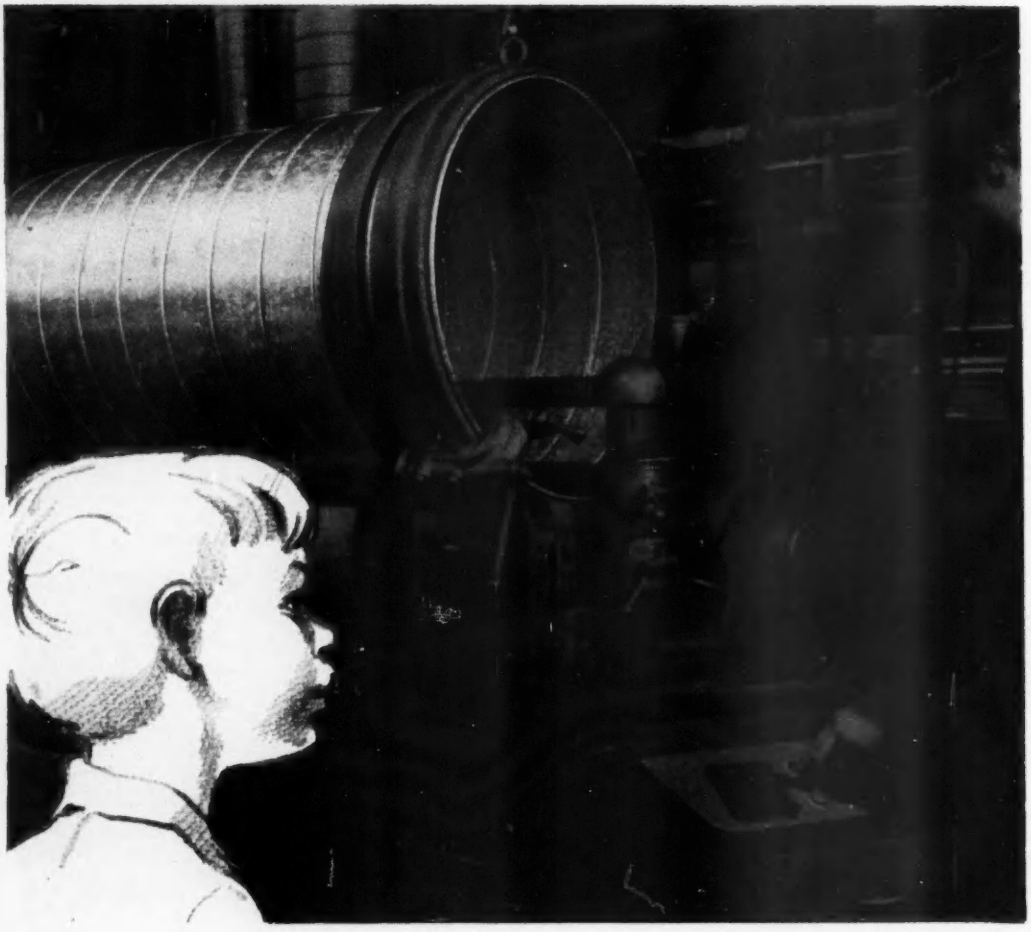
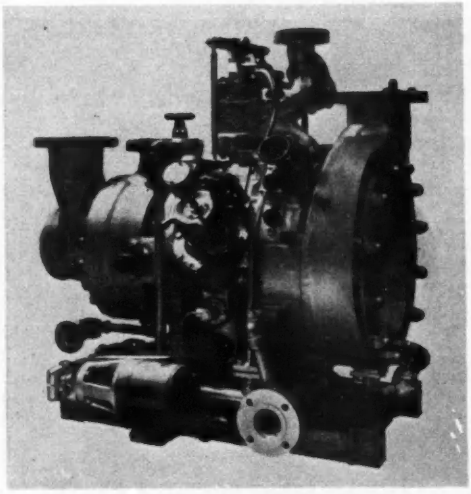


British Industrial Developments

High-Speed Steam-Turbine-Driven Boiler-Feed Pump

Constructed under licence from Pacific Pumps Inc., of California, U.S.A., by The Pulsometer Engineering Co. Ltd., of Reading, Berks., the Pulsometer Pacific steam turbopump is a self-contained compact pumping unit, comprising a centrifugal pump driven by a high-speed steam turbine, designed for continous operation at from 5000 to 10,000 rpm. Intended for boiler-feed duties in ships and in many industrial applications, it provides an attractive alternative to solid-casing boiler-feed pumps, by virtue of its reduced dimensions and comparatively light weight. Thus, compared with multi-stage units of equal capacity, it occupies from 50 to 75% less floor space and is from 25 to 40% lighter.



The pump is of the single-stage diffuser type, with a single-inlet impeller, while the turbine is of the single-stage impulse type, the turbine bucket wheel and pump impeller being mounted on a common shaft supported in two pressure-lubricated sleeve-type bearings. The steam turbine can be furnished with either a single-row or double-row bucket wheel, both types being suitable for operation with steam at pressures up to 900 psig and temperatures up to about 950°F, with standard exhaust pressures up to 150 psig. Under these conditions, the pump is capable of delivering up to 750 gpm of feed-water against feed pressures up to 1100 psig.

The speed of the pump is regulated and controlled by a hand-adjustable, direct-acting, centrifugal-type constant-speed governor, driven from the main shaft through a worm-and-gear reduction. The response of the governor to changes in load, steam pressure, or other factors affecting speed is practically instantaneous. The speed can be increased or decreased while the turbine is in operation by turning the governor adjusting cap up or down by hand, the range being approximately 30%, and regulation (speed droop) between full load and shut-off usually less than 1%. An independent, centrifugal overspeed trip is furnished to shut off the steam supply of the turbine should the constant-speed governor fail to function or should the turbine speed exceed the operating speed by 15%. The elements responsive to speed are housed in the main shaft and, because these parts must not fail to function when the turbine is operating, they are matched and tested and the tripping speed established accurately for each unit. A hand trip is also incorporated, primarily as a safety device, to trip the governor steam-valve manually. The hand reset is furnished to restore the constant-speed governor to normal operating position after either an overspeed or a hand trip.

The unit, which is readily adjustable to changing conditions, is available for instant starting, without preheating of either the turbine or the pump, and, as distinct from multi-stage pumps, can usually withstand a temporary loss of suction without any risk of damage. Steam seals eliminate conventional packing, while the pressure-lubricated shaft bearings become hydrodynamic at surface speeds of 4000 fpm.

Blow-Moulding Machine for Hollow Plastic Articles

Of robust construction and neat design, the Fischer BM500S blow-moulding machine, now being manufactured in Scotland by Matthew Wylie & Co. Ltd., of Glasgow, S.1, comprises eight main units, i.e., the extruder, vertical extrusion heads, blow-moulding mechanism, thread-forming device, discharge conveyor, blowing mechanism, hydraulic equipment, and electrical control desk. The blow-moulding mechanism is suitable for use with either a double or single vertical extrusion head. The vertical double heads are set at a little over 5-in. centres, enabling two round hollow articles of up to 500 cc capacity and with a maximum height of 9 in. to be simultaneously and economically manufactured. The single head can produce one round hollow plastic article up to 1000 cc capacity per cycle. Where the shape of the article is irregular, these capacities can be greatly exceeded, ranging up to 2500 cc for one article.

The dies and mandrels for the extrusion heads are interchangeable, so that various dimensions of tube can be extruded, depending on the size of the article to be manufactured. To obtain accurate forming and extrusion of the pre-forms, the extrusion heads are divided into several heating zones, each electrically heated and accurately temperature-controlled.

The mould-closing mechanism comprises two movable platens actuated by centrally mounted hydraulic cylinders and pistons. The closing movement is made under normal pressure and, after the mould is closed, an intensifier unit effects an increase in the oil pressure to obtain a locking force of 4 tons. The mould-bearing surfaces of the platen are precision-ground and the platens are accurately aligned on their guide-bars, ensuring perfect closing of the moulds and absolute conformity of the mould cavities.

The thread-forming device is located immediately above the mould-closing mechanism and consists of a

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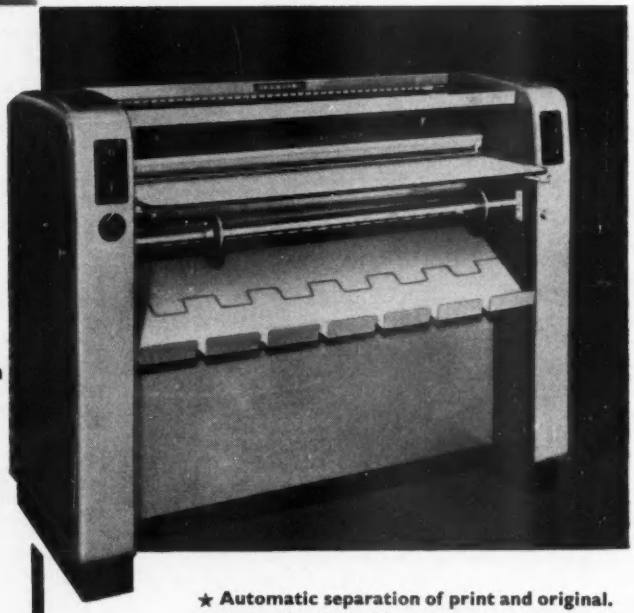

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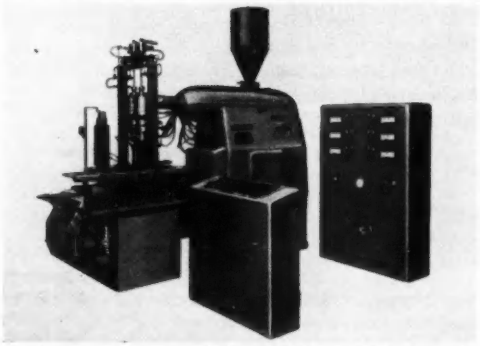
welded steel frame with support-plates for thread-forming bars and hydraulic cylinders for closure of the thread-forming section. The thread-forming device can be raised and lowered hydraulically between the mould and extrusion heads with great accuracy, so that perfect closing between the thread-forming part and the mould is obtained.

A short endless-belt type of discharge conveyor, located below the mould-closing mechanism, serves to remove hollow items after they are ejected from the moulds. A separate power-operated endless-belt conveyor can be provided to supplement the discharge conveyor and to provide a longer cooling period before the articles are piled up.

The blowing mechanism comprises a long tube passing through each vertical extrusion head, the end of the tube forming the sizing die for the internal diameter of the neck of the articles. An inner tube is used for the air required for inflating the plastic article being moulded, while another internal tube enables cooling water to be circulated to the sizing die. The blowing



heads are mounted on a bridge, which is raised pneumatically to extract the blowing heads from the moulded articles after completion of the blowing and cooling portion of the cycle.

The hydraulic equipment comprises a Vickers pump, with a capacity of 8 gpm at a pressure of 710 psi, driven by a 4-kW induction motor and mounted on an oil reservoir equipped with an oil cooler, a magnetic filter, and a pressure relief valve. The control valves for the hydraulic and pneumatic systems are conveniently housed at one side of the blow-moulding mechanism. A panel on the unit cover contains pressure gauges for the hydraulic and pneumatic systems, together with adjustable pressure control valves. All controls are so located as to ensure the minimum of operator fatigue.

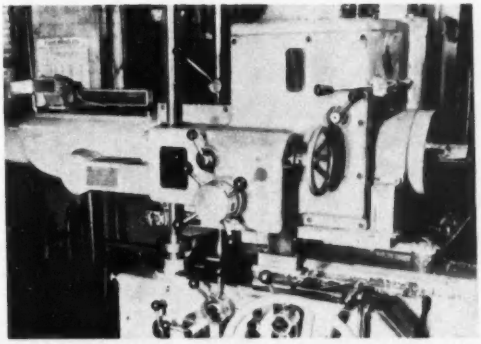
The various electrical control units are housed in a control desk positioned adjacent to the blow-moulding equipment, and include an adjustable time-clock relay for predetermined setting of blowing time up to 60 sec. All other times in the operating cycle are constant and therefore require no adjustment.

In operation, a pre-form of plastic tube is extruded from the vertical extrusion head to a length at least that of the height of the mould cavity. The thread-forming section then closes over the pre-form, tightening it onto the blowing tube and thus forcing the thermoplastic material to fill the thread-moulding space. The cutter-shaped thread-forming section also separates the pre-form from the continuously extruded tube. The thread-forming device then carries the separated pre-forms down into the opened moulds, which close and seal the bottom end of the pre-forms, after which the blowing and cooling phase takes place. In large-necked articles, the blowing air can be bled away to provide a ventilating arrangement for the inside of the article, thus enabling the cooling time to be reduced. After the blowing phase, the moulds open, the cooling and ventilation phase is completed, and the thread-forming device remains closed until both mould halves have loosened from the blown article. At this stage, the thread-forming device opens, disengages the hollow article, and returns to the upper position to start the next cycle. The disengaged article drops onto the discharge conveyor, ready for final cooling and stacking.

Optical Depth Control for Horizontal Boring Machines

As announced by H. W. Kearns & Co. Ltd., of Broadheath, a new aid to co-ordinate setting, in the form of an optical depth control to the travelling spindle, is now available for their Series 45 or 72 horizontal boring machines and for their No. 2 or 3 patent horizontal boring machines. The system used employs an accurately graduated rule and a large projection screen, measuring 4 × 1½ in., completely avoiding the eyestrain normally caused by peering through a microscope.

The fixed scale, which is mounted on the spindle-feed bracket, is almost indestructible and is not subject to wear. An optical unit carries the projection screen, on which a vernier subdivides the magnified main-scale readings into thousandths of an inch or hundredths of a millimetre. The projection screen is protected by a toughened-glass plate, and parallax errors are impossible, because both the vernier and the image of the scale are on the same surface. Screen readings are transposed and reflected by a mirror. A pneumatic time-switch is provided to protect the projection lamp.



Clamping of the bearing to the travelling spindle enables the spindle to be gripped in the most convenient position for the workpiece to be machined. A further fine adjustment on the scale mounting makes it possible for readings to be set at zero or the nearest whole number. For most work, the 12-in. or 305-mm traverse provided is sufficient, but reclamping of the rear spindle bearing allows the full spindle traverse to be used. Using normal spindle feed rates, continuous readings can be taken from the main scale to 0·01 in. or 0·1 mm. Final reading and setting is direct to 0·001 in. or 0·01 mm.

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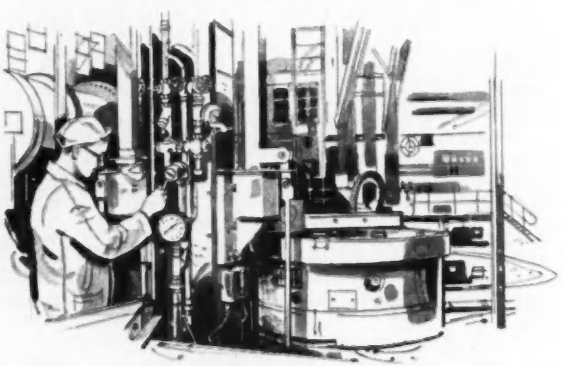

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Process for Producing Graphite with Reduced Porosity

Conventional commercial processes for producing graphite result in a material which is able to withstand high temperatures and to resist the action of corrosive gases and liquids. Unfortunately, however, the nature of the chemical changes the material undergoes in production makes it very porous to both gases and liquids, imposing certain limitations on its application in the engineering field and in consumer goods. It is now reported that, by developing processes which reduce this natural porosity and suitably applying them to graphite in its basic form, the Hawker Siddeley Nuclear Power Co. Ltd. have introduced a material which, to all intents and purposes, is new, inasmuch as it retains all the advantages of the old material but eliminates its main disadvantage. In fact, it is about twice as strong and its porosity is reduced by a factor of one million.

In the field of nuclear engineering, it is considered that the increased density of the new material should help in the eventual development of more compact and consequently cheaper nuclear reactors. At the same time, many other applications are possible. Thus, special grades are eminently suitable for use in the chemical industry and in equipment for handling molten metals, as distinct from conventional crucible equipment, which tends to absorb some of the molten metal—a particularly undesirable feature where rare or precious metals are concerned. Other applications include its use in high-temperature dies, bursting discs, pump seals, gland packings, high-temperature bearings and bushes, and rocket-nozzle components.

Insofar as the treatment process is concerned, the experimental aim has been to achieve almost complete impermeability to gases or liquids and at the same time to improve the mechanical properties of normal graphite. In this connection, it can reasonably be claimed that the treated material is capable of holding a vacuum of higher than 10 microns while heated to a temperature of 1800°C under inert-gas conditions.

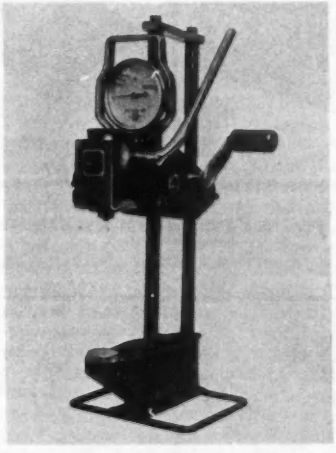
In order to reproduce these processes on a production basis, the Hawker Siddeley Nuclear Power Co. Ltd. have had to install carbonizing and graphitizing furnaces of special types. The 1000°C controlled-atmosphere carbonizing or baking furnace, with a charge capacity of 4 ft 6 in. diameter by 14 ft 6 in. length, has been produced by Sintering & Brazing Furnaces Ltd., of Slough, Bucks., and is essentially a vertical cylinder, 8 ft 6 in. in diameter and 22 ft in height. Arranged for charging batchwise through the top, the charge is arranged on a loading jig and lowered by means of a 3-ton gantry onto a work-support spider. The charge is contained in a muffle chamber, fitted with re-circulation ducts, and a fan is situated beneath the spider, drawing down through the charge and exhausting through the ducts. The heating elements are arranged in three zones, each identical, independent, and formed from nickel-chromium tape. The temperature of the work space is measured by several selectable thermocouples, with additional thermocouples placed near the heating elements. The outputs of the thermocouples are taken to a control deck, where there is an instrumentation and control panel. It is from this panel that any type of heat control can be automatically programmed and the safety of plant and personnel supervised. The importance of the fine temperature control available cannot be over-stressed. Thus, in some applications a slow steady cure of carbon products may take five days, during which time the temperature is raised steadily and accurately to 1000°C, as any sudden change of temperature would ruin a valuable product. There is a maximum temperature differential of 10°C over all the work space. The furnace is designed to use an inert atmosphere, which at present is nitrogen, having a maximum oxygen content of 10 ppm.

The 3000°C controlled-atmosphere graphitizing furnace, designed by Spembly Ltd., of Chatham, Kent, has a power rating of 800 kVA and a charge capacity of 4 ft 6 in. diameter by 14 ft 6 in. length, being capable of accommodating graphite components up to 10 ft in length. As such, it is four times larger than any similar furnace in the world. The furnace, which is also capable of being operated under a vacuum of 0·1 mm at temperatures up to 1700°C, is arranged vertically, offering the advantages of simple charging by means of a specimen cradle and less possibility of bending long specimens when white-hot. The inert atmosphere prevents impurity pick-up during graphitization—a known problem in conventional graphitizing furnaces. Because of the high temperatures involved, the entire interior construction of the furnace is of graphite, and a suitable heating element, consisting of jointed vertical graphite rods, had to be developed.

At present, only one furnace of each type is installed, but it is planned to increase the capacity of the plant as soon as possible.

Portable Brinell-Hardness Tester

Saving handling and set-up time and providing fast, accurate readings, the King portable Brinell-hardness tester, made in the U.S.A. by the King Tester Corporation, of Philadelphia, Pa., and already well known in American industry, is now available in the U.K. from Foundry Suppliers Ltd., of London, S.W.1. Although light and of compact design, enabling it to be used for testing materials in any position and even in small, cramped spaces, it is not affected by vibration, will withstand continuous hard use, and carries out Brinell tests of the highest accuracy.



The instrument is inherently simple to operate and can be used as a bench tester or taken directly to the job. Normally, a load of 3000 kg is applied to a 10-mm ball, producing a sharp and clear impression that is easy to read. There is no inertia effect, as there are no

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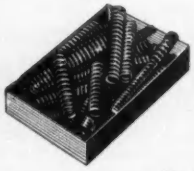

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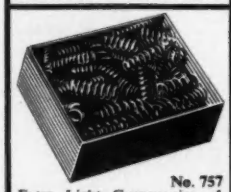

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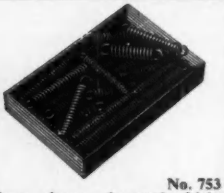

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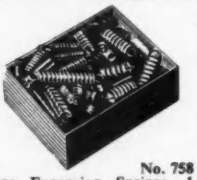

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weights to lift. Also, it is impossible to apply too much pressure to the ball, as the pressure-limiting means incorporated does not allow the load on the ball to exceed 3000 kg. It should be noted that the tester can also apply loads of 500, 750, 1000, and 1500 kg, when required. Thus, when testing tool steels and thin material or in cases when a small impression is considered desirable, the instrument can be used with a 5-mm tungsten carbide ball, with applied loads varying between 500 and 1500 kg. The results are accurate and, should the small impression produced be objectionable, it can easily be filed away.

The test head moves up and down on threaded posts by means of a crank-handle, so that the tester can be operated rapidly on a wide range of parts of different sizes, up to 10 in. in height. An exclusive feature is that the test head is removable, making it possible to test parts of any size in virtually any location. In this case, the test head can be held by any means capable of withstanding the 3-ton thrust of the ram on the ball, e.g., by means of C-clamps.

Instrument for Measuring Surface Finish

A new version of the Swiss "Diavite Microtester" surface-finish measuring instrument has now been introduced by Payne Products International Ltd., of Slough, Bucks. The previous model of this instrument was fitted with a meter showing centre-line average readings and with a graduated scale and selector knob used for the determination of maximum scratch depth (from the mean centre-line). When the selector knob was set to the indicated value of scratch depth, a red warning light was caused to flash once per stylus stroke. The new and improved version of the instrument now provides a meter reading which, by push-button selection, indicates values of centre-line average, maximum height of profile from the mean centre-line, and maximum depth of scratches, peak to valley.

Although B.S. 1134 : 1950 stipulates the use of the centre-line average system, the ability to determine the maximum depth of scratches, peak to valley, is of considerable value when it is necessary to determine accurately surface damage to the work. For example, in the manufacture of transistors, where etching is used to remove all traces of surface damage from semi-conductor slices, it is possible to predict the depth to which etching must be carried out.

As in the previous instrument, the new version covers the range between 0 and 300 micro-inches, with three available "cut-off" lengths (waviness limited), i.e., 0·003, 0·010, and 0·030 in. Various types of tracer heads are available for measuring flat surfaces, spherical surfaces, bores, tooth flanks, ball races, etc. The standard instrument is fitted with a stylus head of 4-mm stroke, but a special model is obtainable which provides three alternative strokes between 1 and 2 mm. A pen recorder is also available for providing permanent records of surfaces.

The Effect of Swirl Timing on Combustion in Diesel Engines

(*Concluded from page 89*)

total amount of fuel injected was twice as much as that in the case of direct injection into the main chamber only.

Further photographs were taken with retarded timing of the auxiliary injection. These showed that the flame pattern maintained, to some extent, the features of the fuel spray until the outflow of gas from the auxiliary chamber became noticeable.

Conclusions

The outflow of gas from the auxiliary chamber mainly depends on the pressure gradient between the two chambers, and this gradient is also a function of the rate of combustion in both chambers and of piston displacement. Observation of the combustion process in the auxiliary chamber is particularly difficult, so that it is not possible to determine accurately the intensity and the beginning of the combustion swirl created by auxiliary injection. However, the following conclusions regarding the effect of swirl on diesel combustion can be derived from this investigation:—

(1) Swirl created before fuel injection into the main chamber causes a small improvement in combustion conditions and in the state of the exhaust, but is associated with a rapid pressure rise to high peak values, causing increased combustion noise.

(2) Swirl created after ignition of the fuel spray is effective in shortening the period of after-burning and in reducing discoloration of the exhaust gas. Retardation of auxiliary injection until after T.D.C. gives low-noise combustion with a colourless exhaust, though this is not always accompanied by reduced specific fuel consumption, owing to heat losses, which lower the thermodynamic efficiency of the cycle.

(3) The ratio of auxiliary to total fuel delivered does not seem to have much effect on the minimum specific fuel consumption if the timing of the auxiliary injection is suitably chosen in each instance. The stronger swirl caused by increasing the quantity of auxiliary injection is more effective, however, in increasing engine output.

Finally, it may be noted that, with dual injection applied to the combustion in a free-piston gas generator[4], it can be expected that a higher-temperature exhaust will be produced, without increased fuel consumption, by injection of a small amount of fuel into the auxiliary chamber at a later timing, giving low-noise combustion and a clearer exhaust. This is an effective means of improving the thermal efficiency of combined free-piston engines and gas-turbines.

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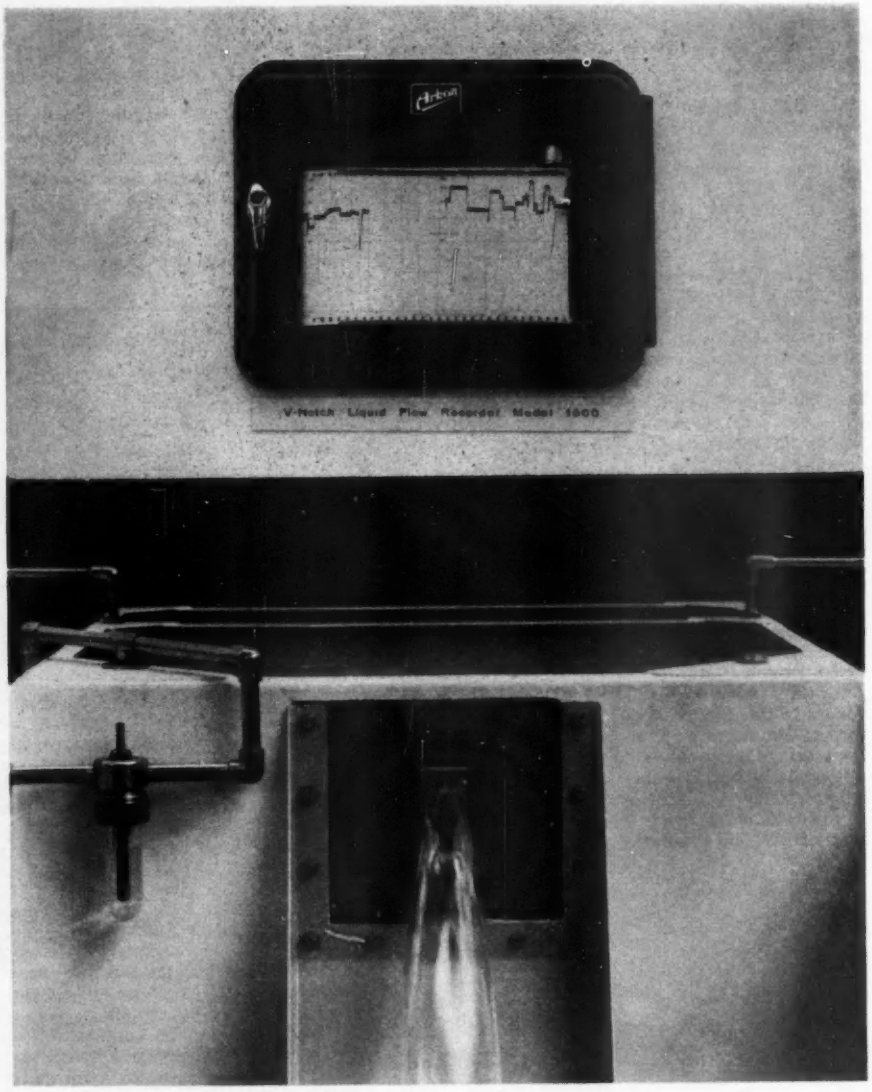

how does the effluent flow ?

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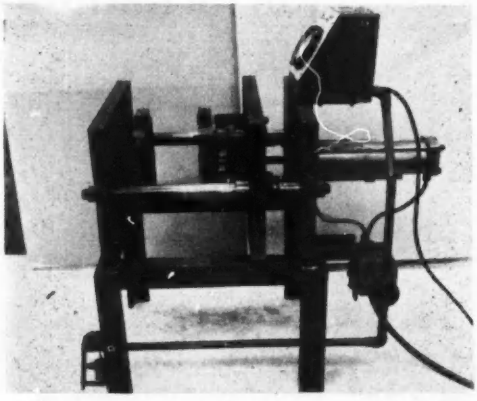
MORE ABOUT ARKON RECORDERS IN PAMPHLET AE.24.

New Materials, Processes, and Equipment

Semi-Automatic Gravity-Casting Machines

The new "Auto-Caster" gravity-casting machine announced by Fringevision Limited, of Marlborough, Wilts., is designed to function semi-automatically, completely freeing the hands of the operator. In addition, pneumatic control provides rapid opening and closing of the platen, while electrical timing of the chill cycle ensures maximum efficiency, inasmuch as the die cannot open prematurely or remain closed for longer than is necessary.

In operation, pressure on a foot-switch causes the moving platen containing one half of the die to move under the action of an air cylinder to the closed position and to lock the dies together, this movement being effected very rapidly (in about 1 sec maximum). The operator then pours into the feed-pourer of the die until it is full, after baling from the furnace in the usual manner. As soon as the dies lock together, a time-switch comes into operation, timing the closed period of the die. This switch is adjustable between 10 sec and 5 min and can be instantly reset to accommodate different conditions and dies. When the switch reaches its zero position, it triggers the pneumatic control, opening the platen. The die is fitted with ejection pins, ejecting the casting, and the machine is then ready for a further operating cycle.



It will be appreciated that, as the time-switch comes into operation immediately after the platen closes, the operator is free to leave the machine after pouring and to progress to one or more machines. In this connection, it is stated that one operator can comfortably maintain six machines with less fatigue than that resulting from operating only one or two machines by conventional methods.

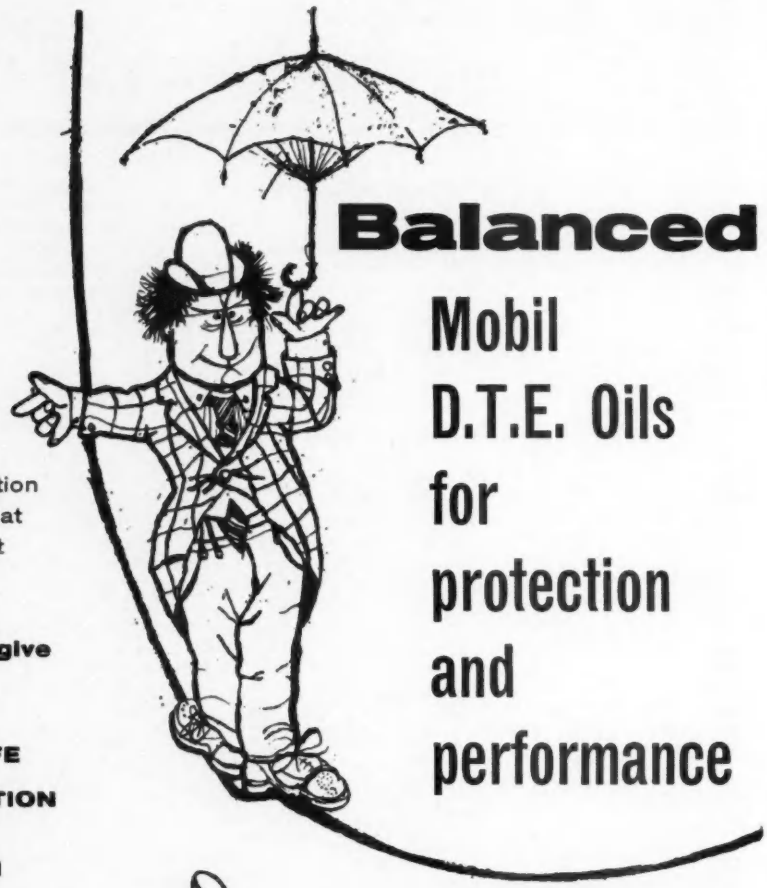
These machines are available in two models, i.e., the "Auto-Caster Major" and the "Auto-Caster Minor". The "Major" machine (illustrated) has a 4-in. air cylinder, a 9-in. platen movement, and a platen surface of 14 × 14 in., while the "Minor" machine has a 3-in. cylinder, a 6-in. platen movement, and a platen surface of 12 × 8 in. Locking pressures on the "Major" depend on the air pressure, ranging from about 315 lb with an air pressure of 25 psi to 1885 lb with an air pressure of 150 psi, the corresponding values for the "Minor" machine being about 175 and 1060 lb respectively.

Unit-Construction Shell Coremaker

Believed to be the first application of unit-construction principles to shell coremakers for all types of foundries, the new CMU shell coremaking unit announced by the Polygram Casting Company Limited, of Frant, Tunbridge Wells, Kent, comprises five basic units, i.e., a core blower, oven feed, oven, knock-out (ejection) table, and corebox return grid. Normally, these units are bolted together to form the complete installation, but they can alternatively be connected in different arrangements to suit any desired foundry layout. Also, if desired, the core blower can be used alone in cases where a foundry already has a suitable oven.

These basic units provide a complete coremaking installation with a single working level, so that there is no need to lift hot coreboxes, which are transferred automatically into, through, and out of the oven. The cycle therefore merely requires the core-blower operator to slide the box from the knock-out table to the 1½-in. diameter blowing orifice, followed in quick succession by automatic pneumatic clamping, blowing with a fluidized column of moulding material, and unclamping, an interlock preventing blowing prior to the box being clamped. The operator then pushes the invested box across to a pneumatic transfer arm, which pushes it into the oven whilst the door is simultaneously raised. On its way to the transfer arm, the box passes over a grid, through which any surplus moulding material drops by gravity to leave a hollow shell core. Whilst the box is passing automatically into the oven, the operator repeats the investment cycle with the next core box. The normal investment time of 10 to 15 sec thus controls the overall output of the machine, enabling the maximum potential output of cores to be approached. For lower outputs, one operator can both blow cores and strip them from the box. Quick-acting stripping gear can be fitted, where necessary, to the standard knock-out table. The pneumatic clamp adjusts itself automatically to all shapes and sizes of corebox, up to a maximum height of 15 in.

The rotational speed of the oven table can be adjusted to provide the optimum curing time for the cores concerned. Additional flexibility is obtained by precise thermostatic control of the oven, which can be heated optionally by electricity, town gas, propane, or butane. Efficient thermal insulation is provided to save fuel and to ensure good working conditions. A



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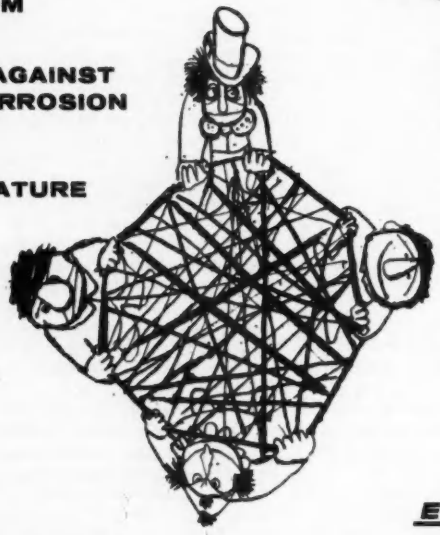

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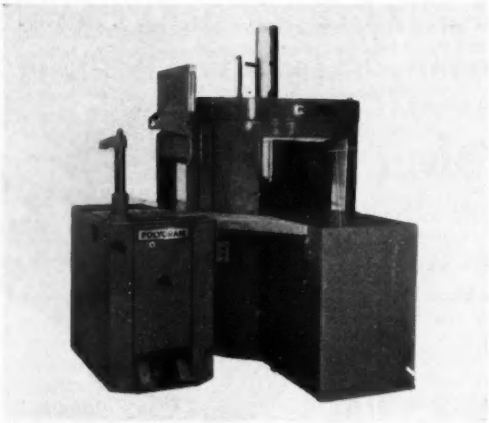
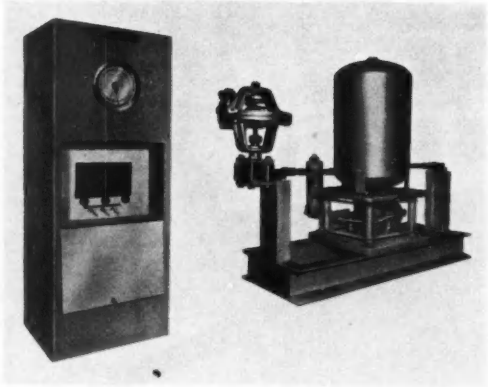


conveniently positioned lever enables the operator to return surplus moulding material through a valve without opening up the main container. This container, in fact, holds about 50 lb of moulding material and can be provided with automatic topping-up, where justified by production requirements.

System for the Continuous Measurement of Specific Gravity

A new continuous, in-process system for measuring specific gravity, developed by Weighing and Controls, Inc., of Hatboro, Pa., is designed for use with liquids, solutions, slurries, suspensions, emulsions, whips, and creams. The equipment operates without radioactive devices or complex mechanical transducers, and its output signals can be used for indication, recording, or control purposes.



In the new system, a flexure-mounted pneumatic weight transmitter, coupled with a specially designed stainless-steel tank, continuously weighs a constant volume of a slurry or liquid. Since the weight of the constant volume is directly proportional to the specific gravity of the material, read-out is directly in specific-gravity units. The system is highly accurate (better than 0·25% overall), and gives excellent repeatability (1 part in 2000), while maintenance is negligible, even under adverse conditions. Furthermore, the pneumatic signal output gives wide flexibility and range. Thus, the output pressure can be from 3 to 15 psi or 5 to 40 psi, read on a scale calibrated to 0·1%, and the signal is essentially stepless, permitting exceptionally smooth control.

Volume is kept constant by one of two methods:— If the material contains air, a probe and an air-vent valve maintain the liquid level by venting the top of the tank, permitting a closed pressurized system. Liquids which do not contain entrained or dissolved air can be measured in a simpler, open-top, overflow tank. In both designs of tank, turbulence can be introduced by baffles, so that contained materials remain in suspension. It is also practical to attach a motor mixer to the tank for agitation.

Automatic Water-Sampling Unit

Based on original work carried out at the Water Pollution Research Laboratory and manufactured under licence from the National Research Development Corporation by Elcontrol Ltd., of Hitchin, Herts., the Type WS.1 automatic liquid sampler is a self-contained, battery-operated portable unit which automatically takes samples of liquids at regular intervals from channels, streams, tanks, etc. It can also be used to advantage in laboratories and pilot plants in cases where it is required to sample a liquid at regular intervals.

The sampler incorporates twelve 20-oz sample bottles, each sealed by an airtight plug, through which passes a rubber tube connected to an outlet. All the outlets are accessible on a panel at the end of the unit, and the bottles and outlets are correspondingly numbered for easy identification. The rubber tube from each sample bottle is controlled by a magnetic pinch-valve, each of which can be manually closed and subsequently opened electromagnetically. The magnetic pinch-valve is retained in the closed position by a permanent magnet, and is re-opened by a pulse from a power supply via a stepping relay which opposes and overcomes the pull of the permanent magnet.

To prepare the unit for carrying out a sampling sequence, it is first necessary to evacuate each sampling bottle by means of an external vacuum pump. This is achieved by connecting each outlet in turn to the vacuum pump and opening the relevant magnetic pinch-valve by means of its appropriate switch, there being twelve such switches mounted in the unit above their respective sample bottles. When this preliminary evacuation has been completed, the manual switches are closed, retaining the vacuum in the bottle, and the external pump is then disconnected.

The unit contains, in addition to the sample bottles and their associated tubing and pinch-valves, a 15-day spring-driven time clock and a transistorized power pack driven by a 6-V battery with a useful life of several weeks. The time clock serves to open the pinch-valves automatically at predetermined intervals, actuating a microswitch at each interval and causing a condenser to be discharged through the coil of a stepping rotary switch at each operation. As a result, selection is advanced by one position and, at the same time, the valve of the selected sampling bottle is opened, causing a sample of the liquid under examination to be sucked into the bottle via a rubber tube immersed in the liquid and connected to the outlet panel through a rustproof filter.

The complete unit measures 24 × 10 × 15 in. high,

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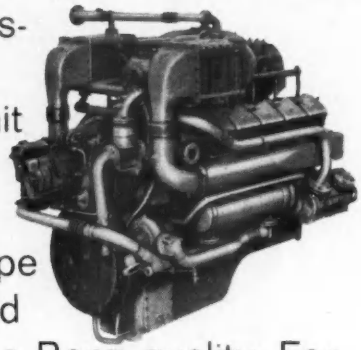

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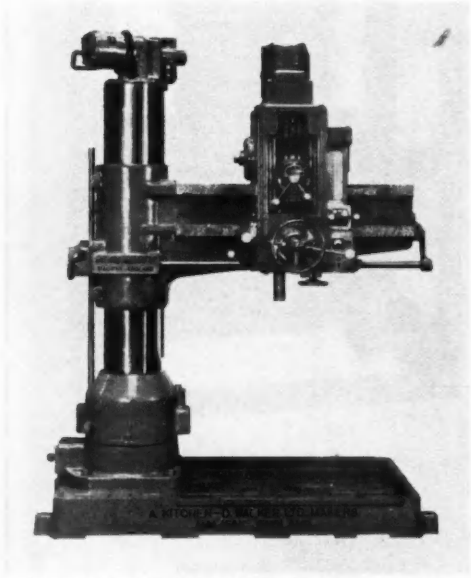
MERCEDES-BENZ DIESEL

and is provided with a carrying handle at each end. A central control panel is fitted with controls for the sample-period selector (providing for one sample every one, two, or four hours), the manual winder for the clockwork motor, and an on/off switch for initiating the sampling cycle. The watertight case is constructed of mild steel, with an aluminium outer shell, keeping weight to a minimum, but retaining maximum strength and rigidity to withstand rough handling under arduous outdoor conditions.

Radial Drilling, Boring, and Tapping Machines

Constituting a companion machine to their heavier E.3 model and of the same basic design, the new E.2 radial drilling, boring, and tapping machine recently introduced by A.Kitchen-D.Walker Ltd., of Halifax, Yorks., is available in a range of sizes from 3 to 5 ft maximum spindle radius, with drilling capacities from the solid in mild steel up to 2 in. diameter (and occasionally 2½ in.), as compared with 3 in. for the E.3 model. The generous proportions of the column, which is of pillar-and-sleeve construction, combined with the company's exclusive three-wall arm, provides the necessary strength and rigidity to withstand the stresses and strains caused by high penetrative conditions, while an unusually wide range of spindle speeds and feeds caters for all materials and sizes within the range of the machine.



Powered by a 5-hp motor, the head is supported on the arm by ball-bearing rollers in both the vertical and horizontal planes, with narrow guide mounting, traverse of the head on the arm being effected by a handwheel and rack and pinion. Eighteen spindle speeds, from 25 to 1560 rpm, and nine power feeds, from 24 to 280 cuts per inch, are provided, together with rapid and fine hand adjustments to the spindle. Sensitive drilling of small holes is adequately catered for by a well-spaced double lever at the front of the head. Start, stop, reverse, and inching are effected by a master controller conveniently located at the bottom right-hand corner of the head. A large-diameter indexed dial is provided for automatic tripping, enabling any depth of hole up to 14 in. to be preset. A drill-point corrector is fitted as standard, so that the full-diameter depth of blind holes can be accurately controlled.

On the standard model, the entire machine is locked by a lever positioned at the left-hand side of the head, but power locking is available as an optional extra. However, irrespective of whether a hand or power lock is fitted, the radial arm can be elevated with the lock applied, ensuring that the spindle is retained in the true position over the hole—an important feature in cases where vertical adjustments are necessary for tool changing. Arm elevation is effected by a 1½-hp motor, positive trips being fitted at the extremes of traverse.

Machining Tungsten with Carbides

(*Concluded from page 90*)

The cutting speed used was 22 fpm, with depths of cut the same as those for the external threads.

It was found practicable to produce hexagonal sides on one tungsten workpiece by side-milling, but special techniques were required to prevent break-outs at plane intersections. Thus, the workpiece was encased in a thick coating of a supporting medium which took several hours to harden. As a further precaution against break-out and crumbling, plane intersections were either radiused or chamfered. Milling from the edges towards the centre of a face might have eliminated the need for a supporting medium. However, since conventional milling tends to chip out large chunks, climb-milling alone is recommended.

Several tool geometries were tried. It was found that a carbide tool, ground for aluminium, having a 15-deg. axial and radial rake, worked satisfactorily, although tool life was shorter than normal because the cutting edges must be sharp to reduce cutting forces. The 3-in. face mill used was operated at a speed of 70 to 75 fpm and a feed of 0·0008 to 0·002 ipr. The depth of cut was as high as 0·050 in. for roughing, but did not exceed 0·002 in. for finishing.

In end-milling, break-out occurred, once near the end of the cut and once, in a different pass, at the beginning of the cut. A 0·5-in. diameter two-tooth end mill with a negative 5-deg. axial rake and a 0-deg. radial rake was run at a speed of 90 fpm and a feed of 1⅛ ipm, the depth of cut being $\frac{7}{16}$ in. The tool stood up, but became very hot; no coolant was used. The tungsten broke out at about ¼ in. from the end of the cut, suggesting that, when working near the edge, it would be preferable to reduce cutting forces or to support the edge in some way. The problem can be eliminated by working from both ends towards the middle. A shallower depth of cut (0·050 in.) was tried out, to reduce tool heating, but the workpiece chipped along both sides of the cut during the first part of the cut. This suggests that, in end-milling, the deeper cuts yield better finishes.

Facing was easily accomplished and gave excellent surface finishes. It was necessary to work from edge to mid-plane. A large lead angle worked well (45 deg. for roughing and 85 deg. for finishing). An outside-diameter speed of 150 fpm, a feed of 0·002 ipr, and a 0·050-in. depth of cut were satisfactory.

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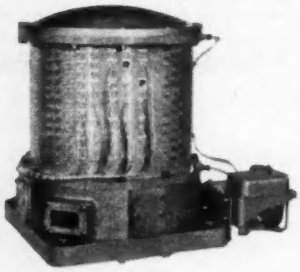

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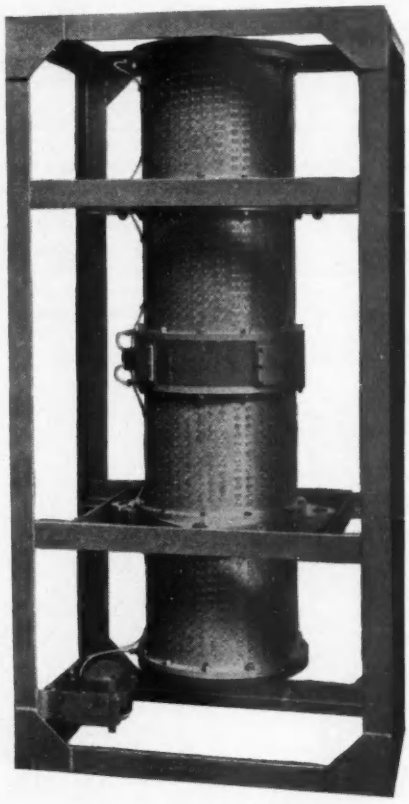

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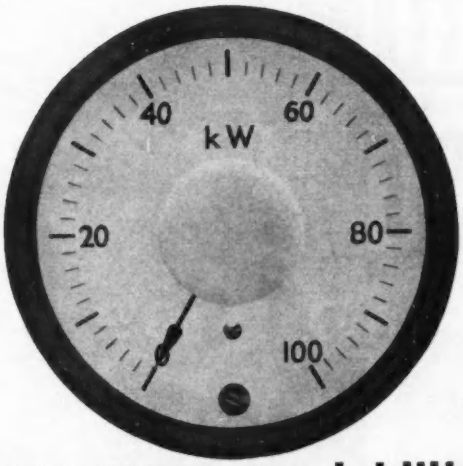

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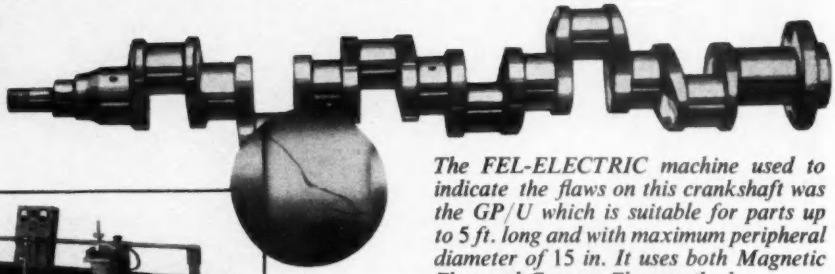

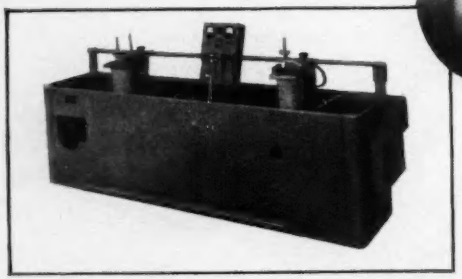

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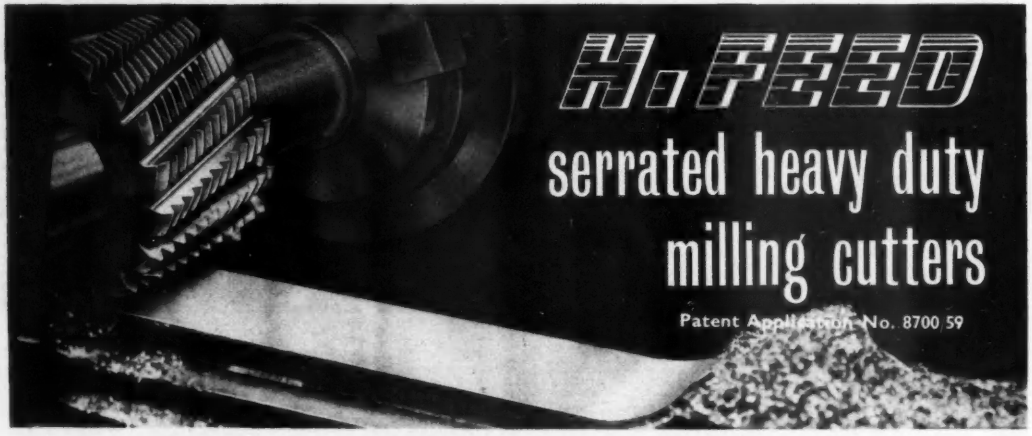

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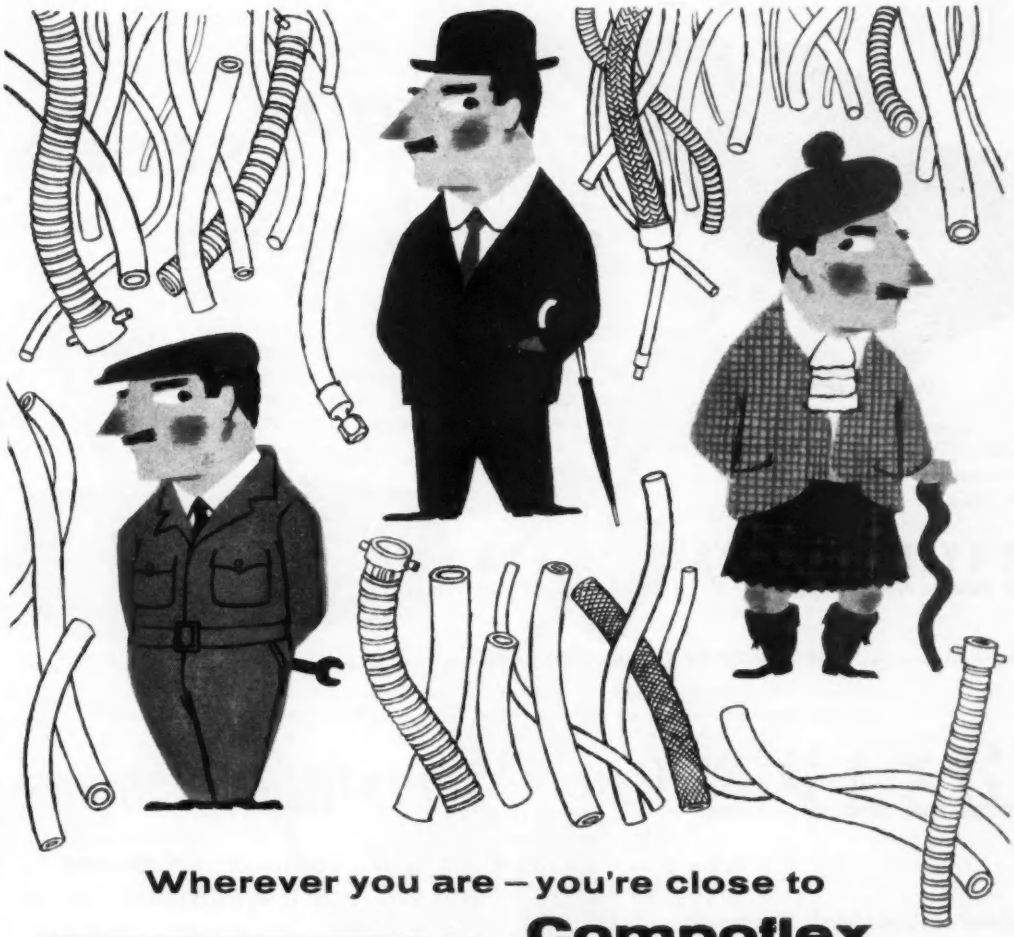

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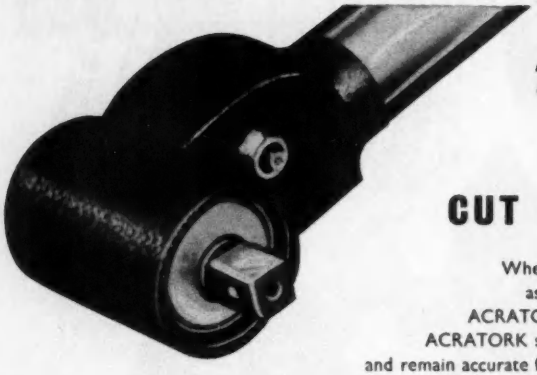

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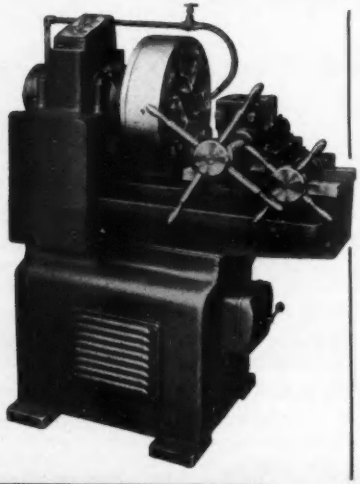

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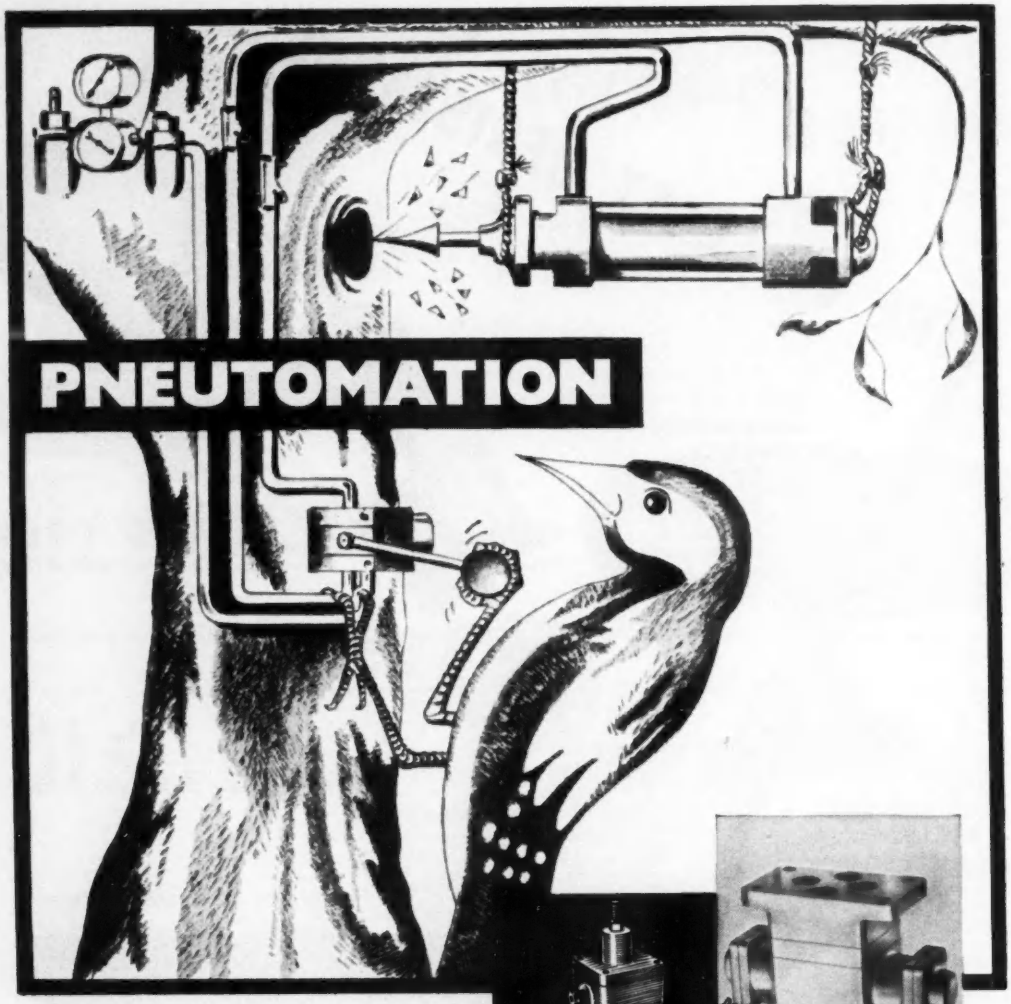

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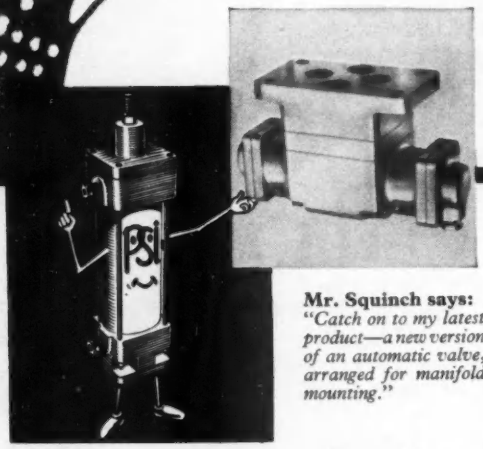

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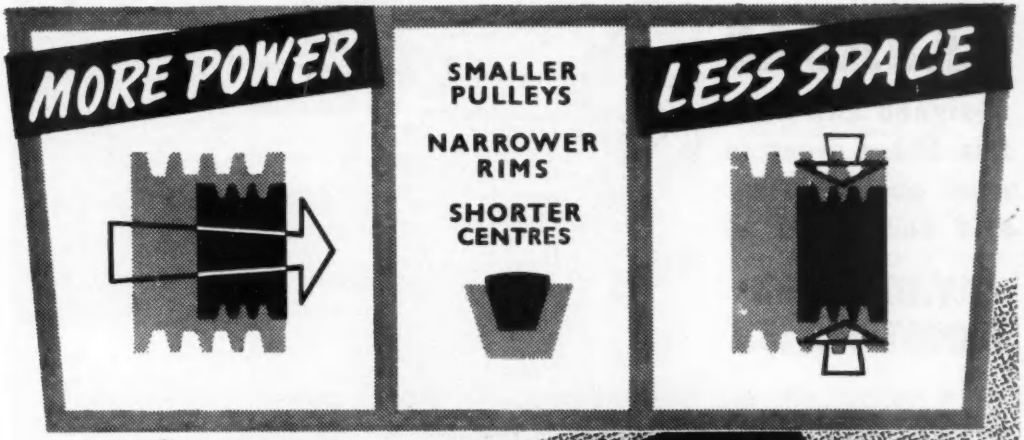

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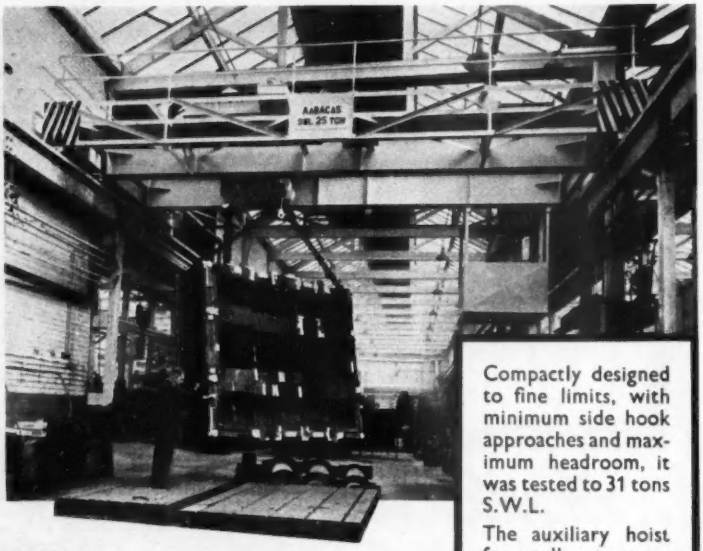

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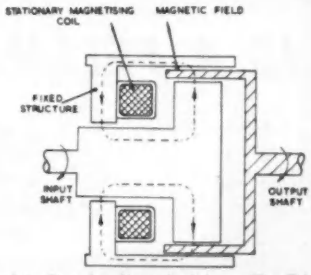

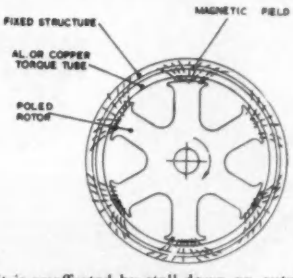

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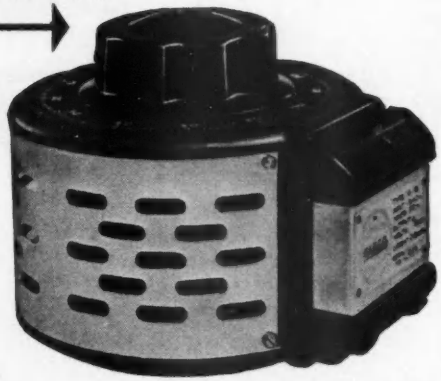

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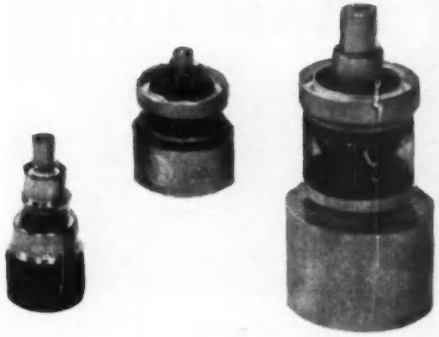

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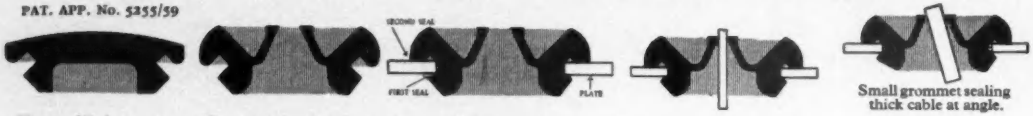

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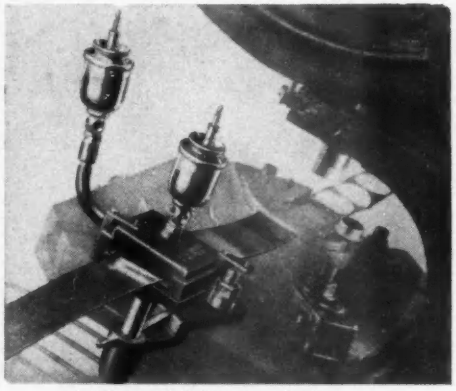

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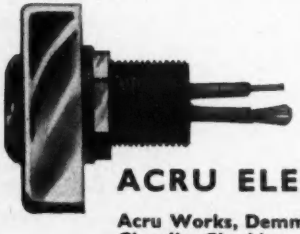

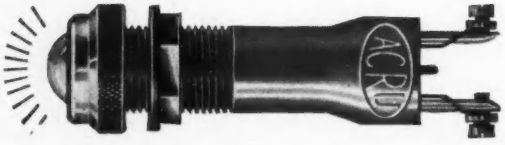

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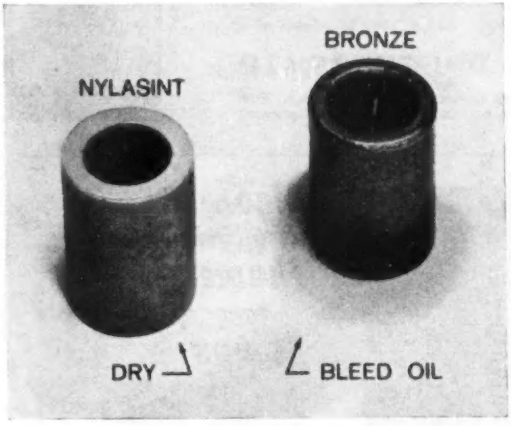

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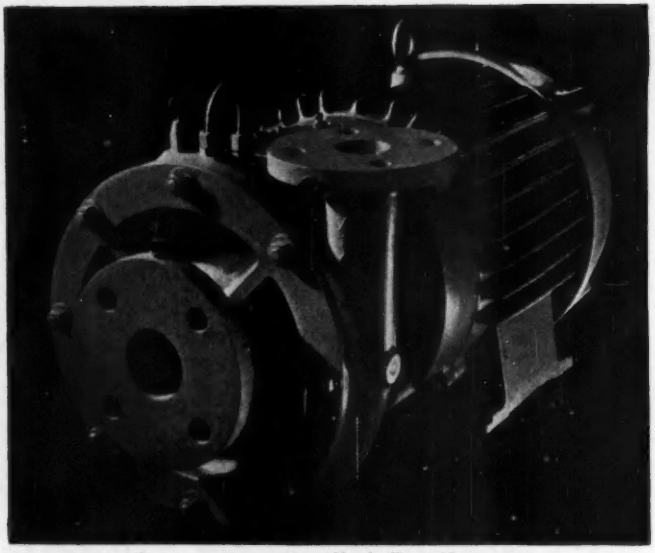

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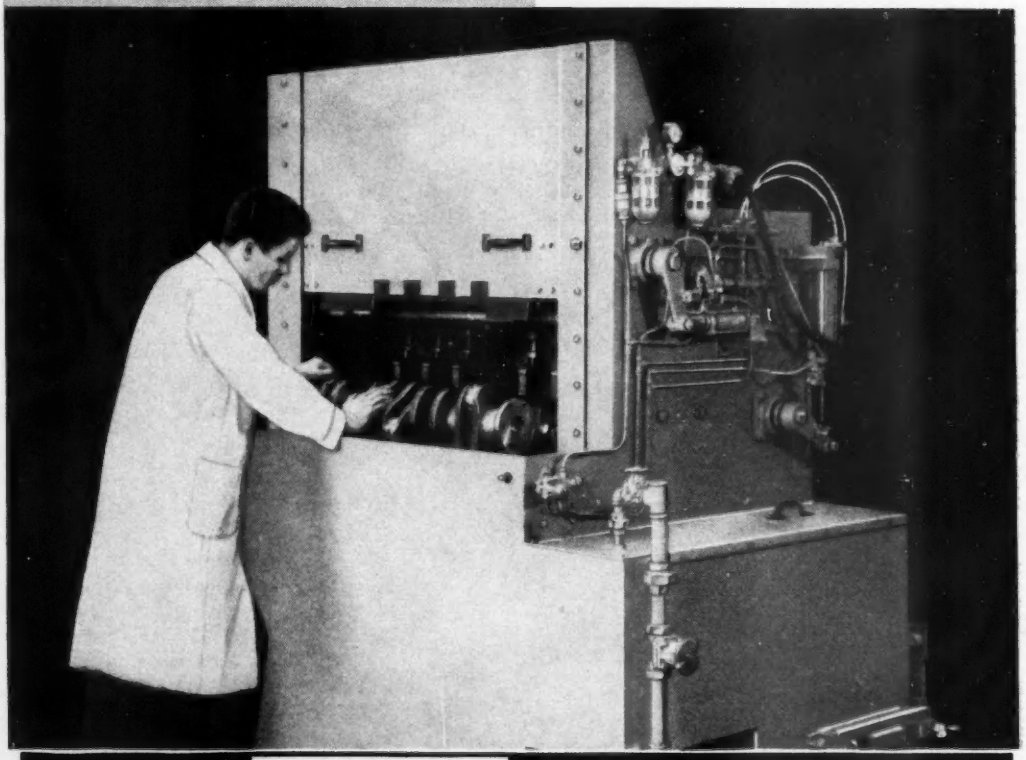

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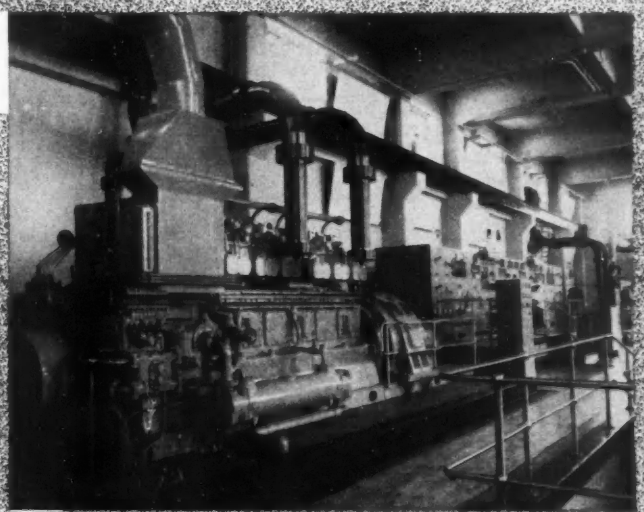

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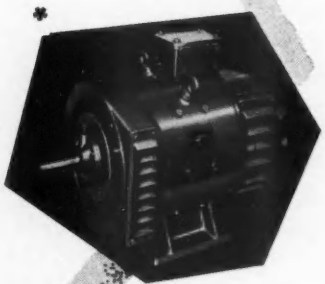

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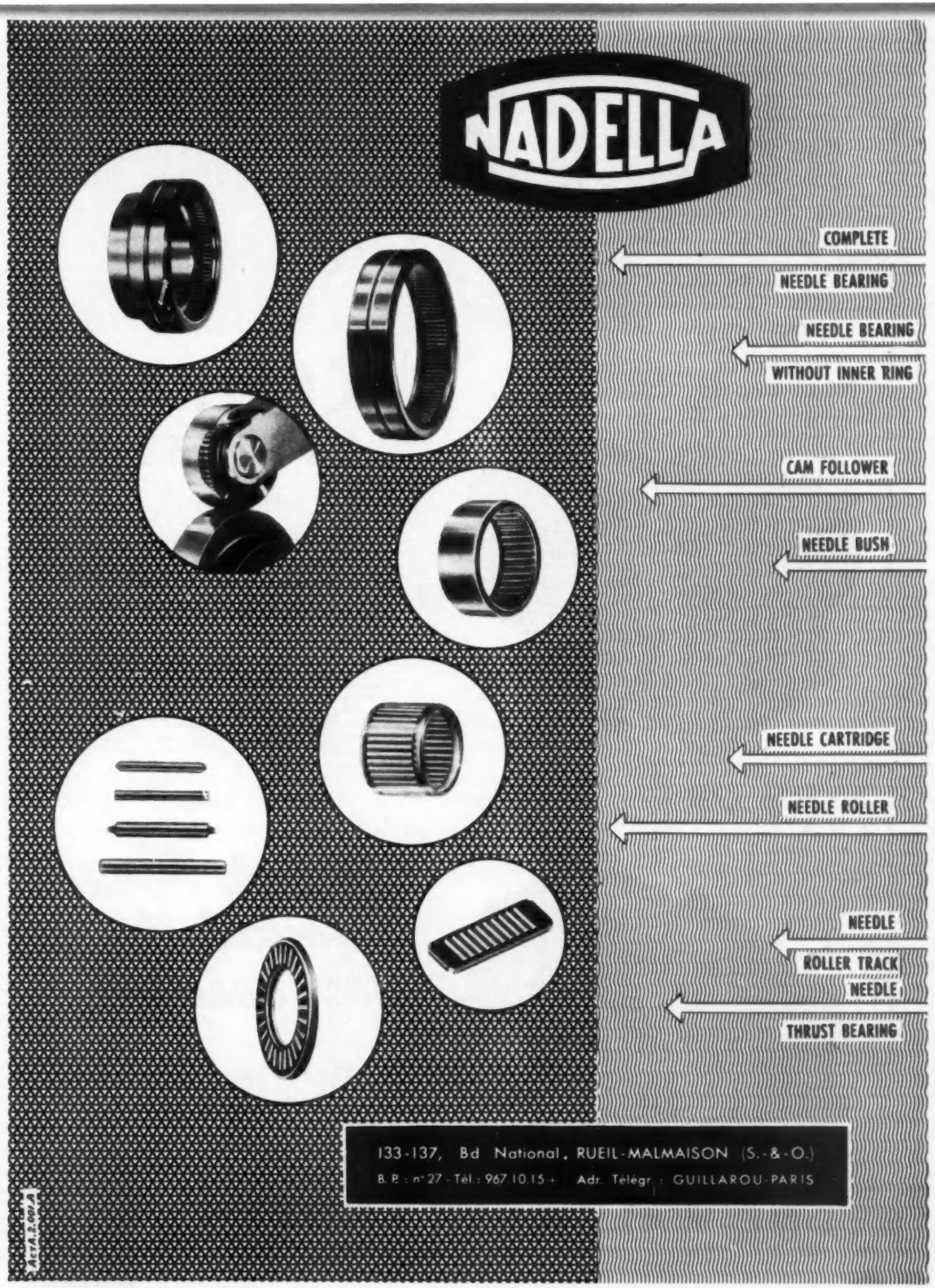
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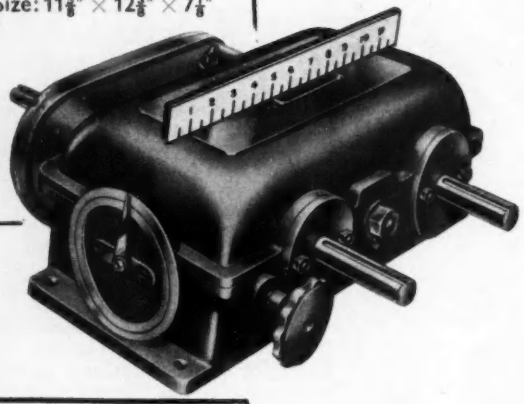

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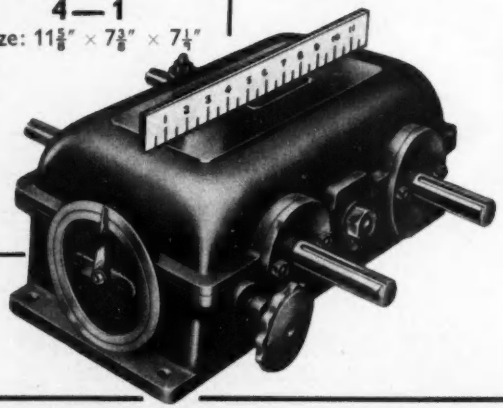

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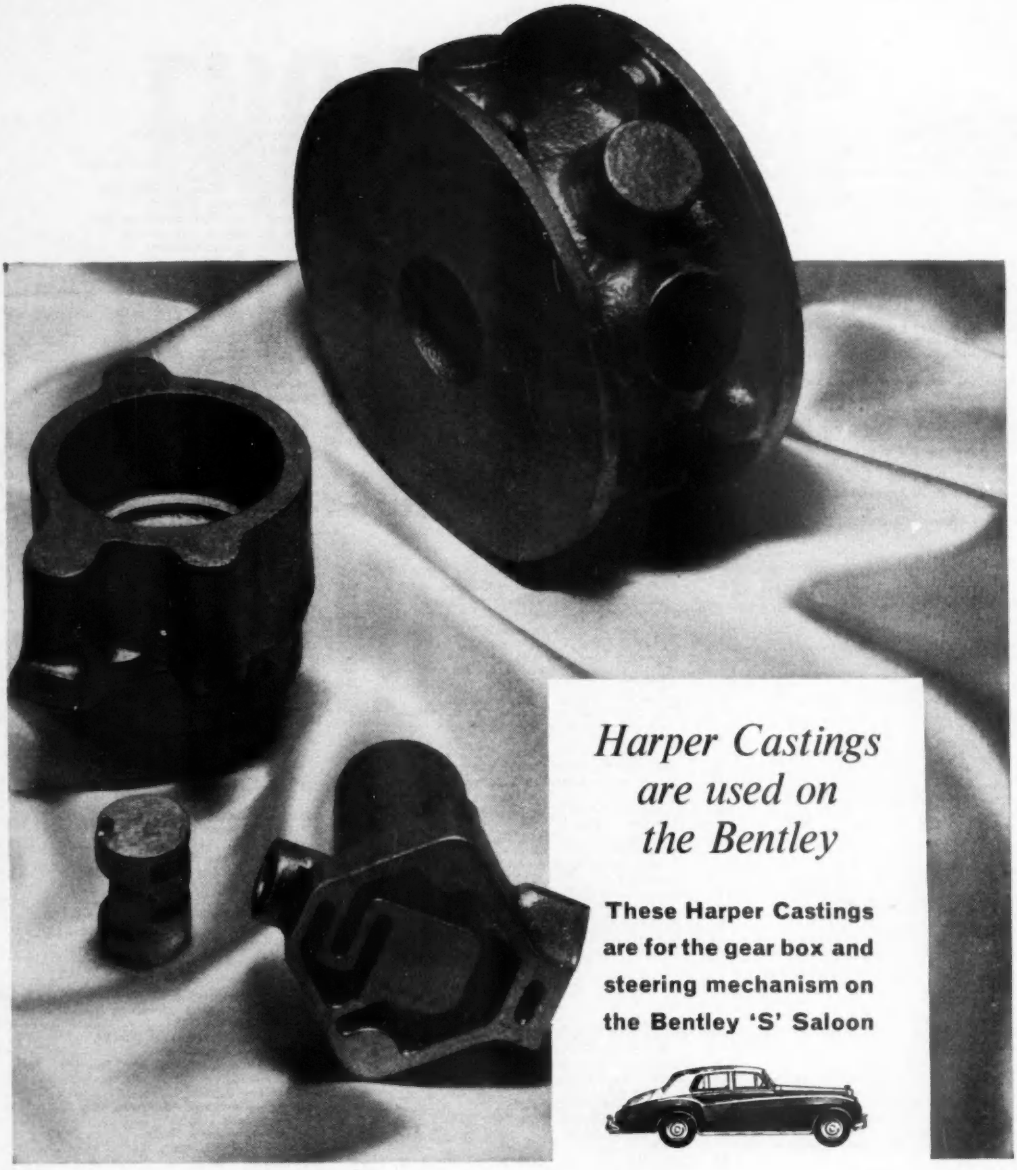

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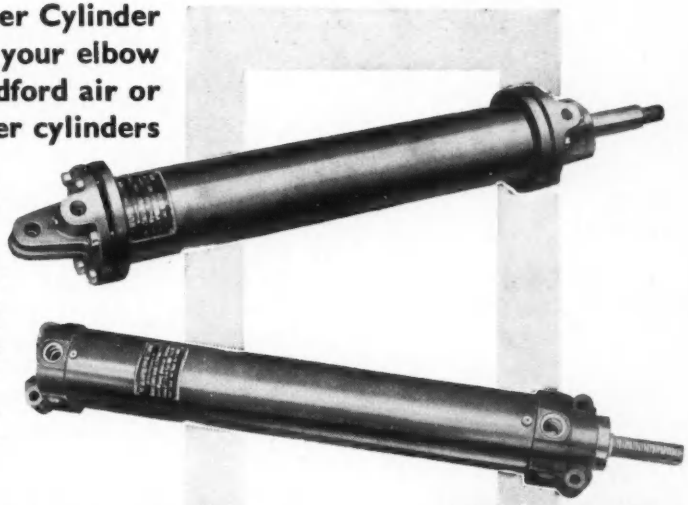

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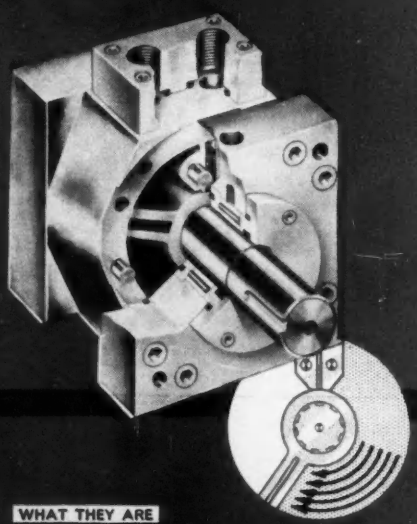
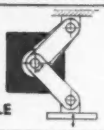


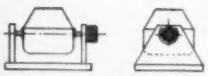
STRAIGHT LINE MOTION—
DOUBLE TRAVEL

TROLLEY OR CONSTANT TENSION

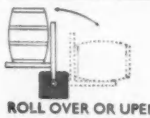


TOGGLE

HIGH TORQUE RATCHET DRIVE



DUMPING OR TUMBLING



ROLL OVER OR UPENDING

TURN OR OSCILLATE

INDEXING

WHAT THEY ARE

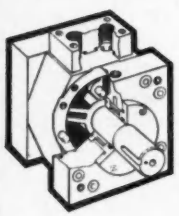
Keelavite/Rotac units are operated hydraulically at low or medium pressures, developing instant torque in either direction. For single vane units the motion is limited to a maximum arc of 280 degrees by the fixed shoe within the cylinder. Power can be doubled by the use of two vanes, in this case the arc of travel is 100 degrees.

WHY THEY ARE BETTER

Torque actuators provide high power in a small space with simple mountings. They can replace other types of actuators, such as cylinders, which require complicated linkage to perform the same functions. In hydraulic systems torque actuators are an ideal solution to many complex mechanical problems.

[redacted]

Opening and closing valves.
Opening and closing doors.
Automation and machine tool uses including:
indexing, feeding, transferring, clamping, locating, turning over.
Freight car tippling.
Crane boom operation.
Pipe and tube bending.
Fatigue test applications.
Foundry equipment.
Materials handling and control of movement on conveyors.



1. *Choice of mountings for fixing at any angle in any position.*
2. *Effective sealing means no oil leak therefore positive control of shaft rotation.*
3. *Working mechanism fully sealed from dirt.*

Keelavite/Rotac rotary actuators are manufactured in the United Kingdom under licence from the XLO Corporation

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